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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XIIth SESSION (CAIRO, 1933).

QUESTION VI:

All-metal rolling stock : carriages and wagons. Use of light metals and alloys. Use of autogenous welding.

REPORT No. 1.

(America, Great Britain, Dominions, and Colonies, China and Japan),

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CONTENTS.

Introduction.

At the eleventh Session of the International Railway Congress Association held in Madrid, in 1930, on Question VIII « All-steel coaches. Comparison with vehicles built of wood », very comprehensive reports were presented by Messrs. Lancrenon and Vallancien, M. Garcia-Varo and P. Fraile, E. J. H. Lemon, and E. Dähnick, and a special report sum-

marising the foregoing was presented by Mons. Lancrenon.

The following report deals with the more recent practice in America, Great Britain and Dominions, Japan and China, and is based upon replies received to a questionnaire which was sent to eighty-six Railway Administrations, of which only thirty-three have sent in replies.

The first portion of the questionnaire had reference to the use of all-metal construction for carriages and of necessity, therefore, covered to some extent the same ground as that dealt with in the 1930 reports.

The replies to the questionnaire are summarised in Appendices II and III which appear at the end of the report (pages 1516 and 1527 respectively).

Owing to the comparatively short period of three years which has elapsed since the report referred to above was presented and to the general prevailing depression in the railway industry since that date, the progress in the construction and design of all-steel rolling stock has not been so extensive as might have been expected during this period. Valuable and interesting information has, however, been obtained in the use of all-metal construction for wagons and in the use of light metals and alloys and welding for both carriages and wagons.

This report is divided into two sections :

A. Carriages.

B. Wagons.

A. — Carriages.

I. — General considerations.

In the *Argentine* the experience of metal construction is limited to that of the Central Argentine Railway. Their experience is such that they are continuing the use of all-metal construction as they consider such coaches are less liable to damage in case of fire and that travelling is consequently safer. The other railways have no experience of all-metal carriages.

In the *United States of America* with the exception of the Delaware and Hudson Company, all the principal Railway Companies have adopted the all-metal carriage for many years and are continuing that policy. They consider they obtain greater strength and longer life; also maintenance costs and risks of fire are greatly minimised. The Delaware and Hudson Company on the other hand, are in favour of a composite construction, which they regard, if properly constructed, as the equal in strength to the all-steel car, their experience being that it is easier to maintain, more comfortable, as it is not subject to the sudden changes of temperature which are met with when all-steel cars are used.

In *Great Britain*, all-steel coaches have only been used to a comparatively limited extent except in the case of electrified railways. The company which has the largest proportion of all-metal main line coaches is the London Midland and Scottish, who have 2.7 % of their total stock constructed in this way. On the London and North Eastern Railway the position is similar to that on the London Midland and Scottish, except that the proportion of all-metal carriages is only about 1 %.

A large proportion of stock on English Railways is constructed, in order to meet the traffic requirements, with side doors to each compartment, and the usual design of all-metal construction is not so advantageous in the case of carriages which are provided with side doors as with carriages having doors at the ends only. All-metal carriages are found to be more costly to construct and are heavier than carriages of which the bodies are made of wood. A sufficient period has not yet elapsed to arrive at any conclusion as to the comparative cost of maintenance, and although the use of all-metal carriages on the railways is an innovation of recent years, experience

seems to indicate that maintenance is likely to prove heavy owing to corrosion of panels. This no doubt is largely influenced by the climatic conditions which prevail.

In *Africa* all-steel standard third class carriages are in service on the Nigerian Government Railways, but no definite policy has been decided regarding other classes of stock.

On the Gold Coast Government Railways the construction of all-metal carriages is being developed, but on the Kenya and Uganda Railways and on the Sudan Government Railways it is not the policy to develop the construction of all-steel carriages. It is felt that there would be much greater difficulty in keeping all-steel stock in repair with native labour, and it is for this reason largely that all-steel carriage construction has not made so much progress.

In *Australasia* all-steel carriages are not used except on electrified railways.

In *Canada* about 30 % of the carriages are of all-steel construction. The conditions prevailing there, and consequently the reasons for their adoption, are similar to those in the United States of America.

No general policy has been arrived at by the Indian Railway Board on this question, and the extreme humidity of the climate in many parts of *India* is bound to influence the Board in arriving at their decision.

In the *Far East,* considerable progress has been made in *Japan.* Since 1926 all new carriages have been of all-steel construction. It is considered that this is justified on the ground of safety and probable durability. The same reasons are influencing the policy of the *South Manchuria* Railway.

II. — Progress and types of metal construction.

The following figures indicate the extent to which all-metal stock is used. In the absence of figures showing the corresponding percentage at the time of the Madrid Session in 1930, no comparison can be made as to the growth of metal carriages.

Buenos Ayres and Pacific Railway	Nil.
Buenos Ayres Western Railway	Nil.
Central Argentine Railway	22 %
Cordoba Central Railway	12 ½ %
Baltimore and Ohio Railroad Company	51 %
Delaware and Hudson Company	10 %
New York Central Railroad Company	100 %
Norfolk and Western Railway Company	60 %
Pennsylvania Railroad Company	100 %
Reading Company	90 %
Wabash Railway Company	38 %
Great Western Railway (England)	Nil.
London Midland and Scottish Railway	2.72 %
London and North Eastern Railway	1.02 %
Metropolitan District and London Electric Railways	89.3 %
Gold Coast Government Railways	14.4 %
Kenya and Uganda Railways	Nil.
Nigerian Government Railways	16 %
Sudan Government Railways	17 %
New South Wales Government Railways (electric cars)	67 %
New South Wales Government Railways. (All passenger stock)	22 %
New Zealand Government Railways	Nil.
Canadian National Railways	31.61 %
Canadian Pacific Railway	26 %
Ceylon Government Railway	Nil.
Bengal Nagpur Railway	Nil.
Eastern Bengal Railway	0.62 %
East Indian Railway	4.6 %

Great Indian Peninsula Railway	7.95 %
Madras and Southern Mahratta Railway	Nil.
Federated Malay States Railways	Nil.
Japanese Government Railways	19 %
Korean (Chosen) Government Railways	3 %
South Manchuria Railway . .	31.45 %

Since the Session at Madrid few changes of note have been made in the construction of all-metal carriages. The preferred practice appears to be that in which the body and underframe are combined to form one structure, the sides and body being used to take part of the load.

On the Pennsylvania Railroad a new type of carriage has been introduced, of the semi-double-deck type, to carry 120 passengers. Sections of this interesting vehicle are shewn in figure 1 and a cross section in figure 2.

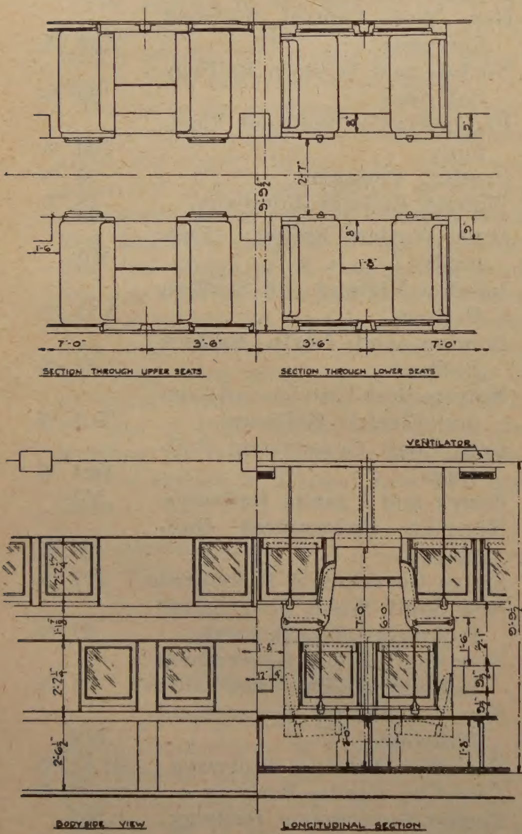


Fig. 1. — Sections of semi-double deck passenger carriage, Pennsylvania Railroad, U. S. A.

On the Central Argentine Railway carriages for main line service have end doors only and those for suburban services have double side doors in the centre. Since 1930 the following types of all-metal carriages have been constructed :

1st and 2nd class electric suburban cars;
Dining cars;
Sleeping cars;
Restaurant cars;
Brake vans.

In all cases the body and underframes of these cars are treated as one structure.

In the *United States of America* the policy of building all-steel vehicles has been continued since 1930 and opinion appears to be divided on the question of utilising the body as part of the structure. On the Pennsylvania Railroad and on the Reading Company the body is constructed quite independently of the underframe, whereas on the New York Central Railroad and the Baltimore and Ohio Railroad the body forms an integral part of the structure.

On the main Railways in *Great Britain* the development of all-metal carriages has been very slow and since 1930 only the London Midland and Scottish Company have added a few vehicles which are fitted with end doors only, the bodies of these vehicles being rigidly secured to the underframe and forming part of the main structure. Figure 3 shows sections through a compartment of a vehicle of this type.

Progress has been made on the Metropolitan District and London Electric Railways, the body and underframe in this case being built as one structure. A cross section of such a vehicle is shown in figure 4 and is an interesting example of light steel construction.

In *Australasia* no new types of carriages are contemplated, but existing all-metal carriages on the New South Wales Government Railways have two sliding doors at each side. These cars are divided into three main compartments with sliding doors in the bulkheads, and hinged vestibule doors at the ends. The body and underframe are constructed as one unit.

In *India* and *Ceylon*, very little progress has been made in metal construction, and no new types have been constructed or designed.

On the *Japanese* Government Railways considerable progress has been made, and new all-metal carriages are being constructed for main line, suburban, and metropolitan services. Passenger cars for use on the steam operated lines have doors at ends only, and postal and baggage cars, and electric cars have large side doors.

In all these cars the body and underframe are constructed as a single structure.

In contrast with the older type of steel carriages, which were built with fish belly centre sills to resist the end shock and carry the total vertical load, the new vehicles have lighter centre sills, and are built up of channels and plates, leaving the greater part of the load to be carried by the side body framing. In place of the monitor (or clerestory) type of roof which was used on the older carriages, an elliptic roof has been adopted with a view to increasing the strength and decreasing the cost.

New carriages of an existing type are being constructed by the Korean (*Chosen*) Government Railways for use on main line services. The body and underframe of these cars form one structure.

On the *South Manchuria* Railways new types of all-metal carriages have been constructed for main line and suburban services. These include :

Diesel-electric motor cars, third class trailer cars, third class gasoline cars, and gas-electric inspection cars.

Except in the case of the Diesel-electric car, which has a door in the middle of the body, end doors only are fitted to the above vehicles. The general principle underlying the construction of these vehicles is to treat the body and underframe as one structure.

III. — Materials used in construction.

The material most generally used for the principal metal members is mild steel, but many Companies are using copper bearing steel in order to reduce the effects of corrosion.

From a perusal of the replies to the questionnaire, it will be noted that the general construction of the :

Body — consists of steel plates, angles and pressings;

Underframe — rolled steel sections, pressings and castings;

Bogies — in the U. S. A. and those countries which have adopted American standards, the bogie frame is of cast steel, but in Great Britain and the Argentine, the bogie is constructed of steel pressings or rolled steel sections and plates.

The usual practice is to employ standard rolled sections for the underframes, cant rails, end posts and various longitudinal members of the vehicle.

Special rolled sections are not used to any great extent, but are sometimes employed for curb rails, outer cant rails, carlines and dovetailed floor sheets.

Pressed steel is used for the vertical body members, and in some cases for carlines and miscellaneous framing.

Cast steel is used largely in the United States of America for bogie frames, underframe and body-end castings, body bolsters and underframe crossbearers. Cast steel is also generally used for underframe and bogie details.

For the exterior panels, interior panels, partitions and roofs, the replies reveal no standard practice, but show an increasing use of corrosion-resisting materials, such as copper-chrome-molybdenum steel, and copper-bearing steel.

As regards the flooring, the more usual practice appears to be the use of galvanised dovetailed sheeting covered with a composition flooring.

Details extracted from the replies to the questionnaire are given below :

Exterior panels. — A great variety of panels are in use including : charcoal-finish steel sheets; copper-chrome-molybdenum steel ; copper bearing steel ; lead coated mild steel plates, and roller-levelled blue annealed steel plates.

Interior panels. — Steel sheets of various grades, including furniture steel, are used for the interior panelling. Other materials used by some Companies are wood, plywood, and composition materials such as « Millboard » and « Sundeala ».

Partitions. — On some railways, chiefly in the United States of America and Australasia, the partitions are constructed entirely in steel, whilst on others a composite structure of timber framing and steel panels is used. A solid wood partition is favoured by some Companies — a variation of this being a wood frame with plywood panels.

Floor. — The most usual type of flooring is of galvanised corrugated steel sheets (key or dovetail pattern). This is covered with a composition material such as « Decolite », « Induroleum » or « Flexolith ». Some railways have adopted a sheet steel sub-floor, with an overlay of wood for the top floor. The Norfolk and Western Railway (U.S.A.) use a top floor of cork tile, with magnesium chloride solution as a binder.

Roof. — The roofs are mostly of steel sheet construction. The different grades of sheeting used include copper bearing steel, ordinary mild steel plates, lead-coated mild steel, galvanised steel sheets, and copper-chrome-molybdenum steel. Another type of roof has a steel frame with wood and canvas sheathing, while the Japanese Government Railways use a roof of wood boards covered with special thick asphalt-coated steel sheets.

IV. — Methods of assembly. Riveting and welding.

A survey of replies to the questionnaire shows that riveting is still the usual practice in the assembly of all-metal carriages. On most Railways the various metal components are assembled in jigs and then riveted in position.

Where light steel parts are used in the construction, soft steel or iron rivets are used, and are driven cold. This method is used on the London Midland and Scottish Railway for body sides, end panels and roof sheets.

Machine screws are also used for fixing panels and other light steel parts on many railways.

Aluminium rivets are generally used where light alloys or aluminium are used in the construction of all-metal carriages.

Welding by electric arc, and autogenous methods, is being experimented with on a wide scale, but no definite statement as to the results can yet be formulated.

Although no completely welded structures have been reported, many Companies are agreed that welding in place of riveting would be advantageous for most joints and would give an appreciable reduction in weight.

In the case of thin plates and panels, difficulties are experienced with regard

to deformation and buckling. On the Korean (Chosen) Government Railways the method adopted for overcoming this difficulty is shewn in figure 5. This consists of a steel cramp which holds

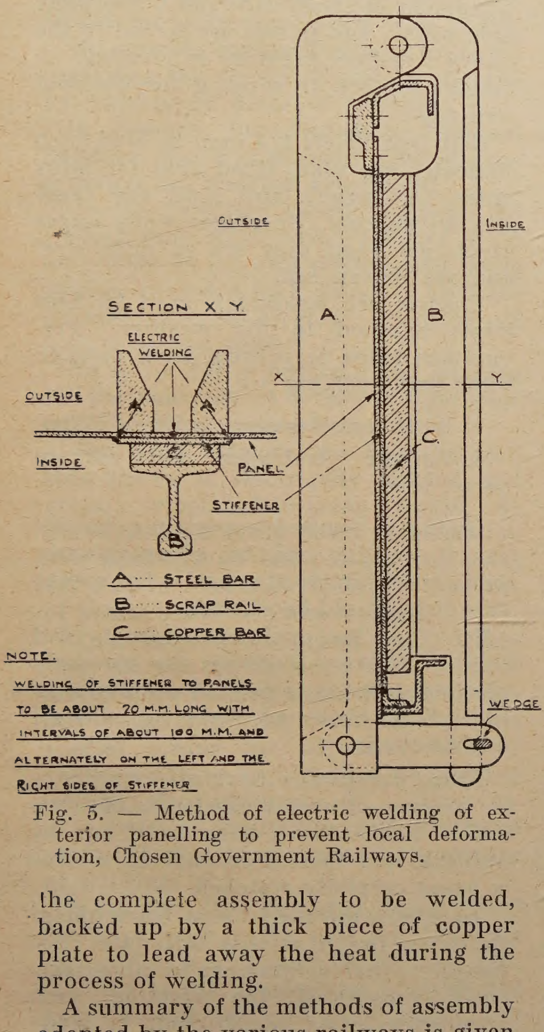


Fig. 5. — Method of electric welding of exterior panelling to prevent local deformation, Chosen Government Railways.

the complete assembly to be welded, backed up by a thick piece of copper plate to lead away the heat during the process of welding.

A summary of the methods of assembly adopted by the various railways is given below :

The Central *Argentine* Railway employs riveting for assembling metal framing. Steel rivets being used for light steel work and aluminium rivets for « Alpax » fittings.

In the *United States of America* the Baltimore and Ohio Railroad assemble the metal framing by riveting, steel rivets being used. Interior fittings, such as panels and ceiling sheets are applied with machine screws.

When welding is employed, it is by the electric arc system, but no welding is performed on thin sheets or at joints.

When replacing car roofs, one end is welded and the other end riveted. This eliminates the necessity of removing the ceiling.

This Company have not constructed any welded passenger cars, but they are of the opinion that to do so would effect a saving in the weight of the body of about 10 %.

The Delaware and Hudson Company use riveting entirely, and state that as welding is still in the experimental stage it is too early to give an opinion regarding its advantages for assembling metal framing.

Riveting is generally used on the New York Central Railroad, but welding of parts and the entire structure is being considered. Welding is used at pillars and between the windows where these butt up against the waist rail capping; it is also used at the joints of roof sheets.

Both electric arc and autogenous methods are used, according to conditions and facilities available. Owing to the small sections welded, no difficulty is encountered due to buckling. Electric spot welding is used for certain parts of light steel construction.

This Company expresses the opinion that as progress is made welding will gradually be substituted for riveting, especially where saving in weight is important; it also believes that a reduction in weight of 10 % to 15 % may be expected.

On the Norfolk and Western Railway riveting is employed, and is preferred to welding. Where conditions permit, parts of light metal construction are

assembled in multiple. New construction as well as repair work can be performed quicker by riveting than by welding.

Electric arc welding is used mainly for closing joints in sheets, and no appreciable amount of buckling takes place with the limited amount of welding used.

The Pennsylvania Railroad Company use riveted lap joints in the assembly of all-metal rolling stock, details being riveted by steel or aluminium rivets according to the material of the parts.

Autogenous and electric welding are used for certain joints, but no special precautions are taken to prevent buckling.

This Company is of the opinion that welding can be used for all joints in the general construction of the framing, but is not suitable for interior finish, as welding would distort and buckle the thin sheets used.

No reduction in weight has been effected by welding in place of riveting.

Riveting of metal framing is the usual practice on the Reading Company, soft steel rivets being used, except in aluminium construction, where aluminium rivets are employed.

Experience has shown that if properly made the welded joint is quite as strong as the riveted joint at present used, and welding could be advantageously substituted for riveting in the assembly of all-metal vehicles.

On the Wabash Railway riveting is employed for assembling the metal framing.

In the assembly of details, soft mild steel rivets are used in some cases and machine screws in others.

With the exception of certain joints, welding could be substituted for riveting, the chief reason being that it avoids joints, which, regardless of all precautions, will deteriorate through corrosion. Welding also reduces weight.

In *Great Britain* the London Midland and Scottish Railway have adopted the following practice. The body side, roof and ends are assembled in jigs, the body side being constructed on two main longitudinal members, viz. cant-rail and curb-rail. These members are fixed and gauged in the body side jigs. The body side pillars and panels are bolted to the above members previous to riveting. A similar method is adopted for the roof and ends.

Soft iron rivets 1/4 inch to 5/16 inch diameter are used, fixed cold for body sides, end panels and roof, and these are driven cold. In places when larger rivets are used they are of mild steel and are driven hot.

Electric arc welding is used for butt joints exposed to the weather. Precautions taken to prevent local deformation and buckling are :

1. Sufficient clearance between plates.
2. Correct electrodes and current values used.

Owing to limited experience, cannot say if welding can be advantageously substituted for riveting and what saving in weight would be effected.

On the Metropolitan District and London Electric Railways the assembly of metal framing is carried out by riveting. Steel rivets are used for all-steel construction.

These Companies have no experience in welding all-metal carriages, but two trailer bogies have been built up by welding, and their behaviour in service is being carefully watched.

In *Africa* the Gold Coast Government Railways use a riveted structure, but considers that welding can be advantageously substituted for riveting such permanent joints, which could be made smaller than would be the case if they were riveted.

In *Australasia* the practice of the New South Wales Government Railways is to assemble the metal framing in jigs and rivet together.

Welding is used to a very limited extent in places such as the corners of window openings, to make them watertight. With the exception of special cases such as the above, riveting is preferred for passenger coach body work.

No suitable comparisons are available regarding the saving of weight effected by welding in place of riveting.

In *Canada* the Canadian National Railways use a completely riveted construction, no welding being used.

On the Canadian Pacific Railway the underframe, sides and roof are built separately on jigs and riveted. All rivets smaller than 3/8 inch diameter are cold pressed and cold riveted. Rivets are of 0.15 % carbon steel.

No « special » methods are adopted for the assembly of details in light steel or light alloy construction.

The joint between the belt rail and side sheets is electrically welded and ground smooth after being riveted. As the material is fairly heavy, deformation and buckling do not present any great difficulties. The splice plates at the back of girder joints are also welded.

This Company considers that if a first class job can be obtained with quantity production, welding could be advantageously substituted for riveting, also that special means for automatic electric welding will be required before welding will supplant riveting.

In *India* all the Railways use a riveted assembly, and have not any experience of welding.

In *Japan* the Japanese Government Railways have in the past used riveting for all joints, but on a number of cars welding of the panel plates to posts has been carried out with good results. In future, welding in this connection will be used to give a better appearance to the outside sheathing. Panel plates are also joined together by welding.

Either electric or autogenous welding is used according to circumstances in the works.

As a precaution against local deformation, a piece of copper plate is applied to the back of the welded spot to lead away the heat during the process of welding.

When any buckling or deformation does occur, it is corrected by local spot heating with a burner, and quick cooling with water spray where necessary.

Up to the present time, no attempt has been made to extend the process of welding beyond the welding of panels, but in future constructions, consideration will be given to the welding of underframe and bogie members on account of weight saving.

On the Korean (*Chosen*) Government Railways the assembling of metal framing is carried out mostly by riveting.

Electric welding is employed for exterior panels, letter boards and other thin plate work, and autogenous welding is used for window moulds, side sills, side plate angles, etc.

This Company considers that welding can be with advantage substituted for riveting, also that a welded structure has a better appearance than one which has been riveted and is also lighter in weight.

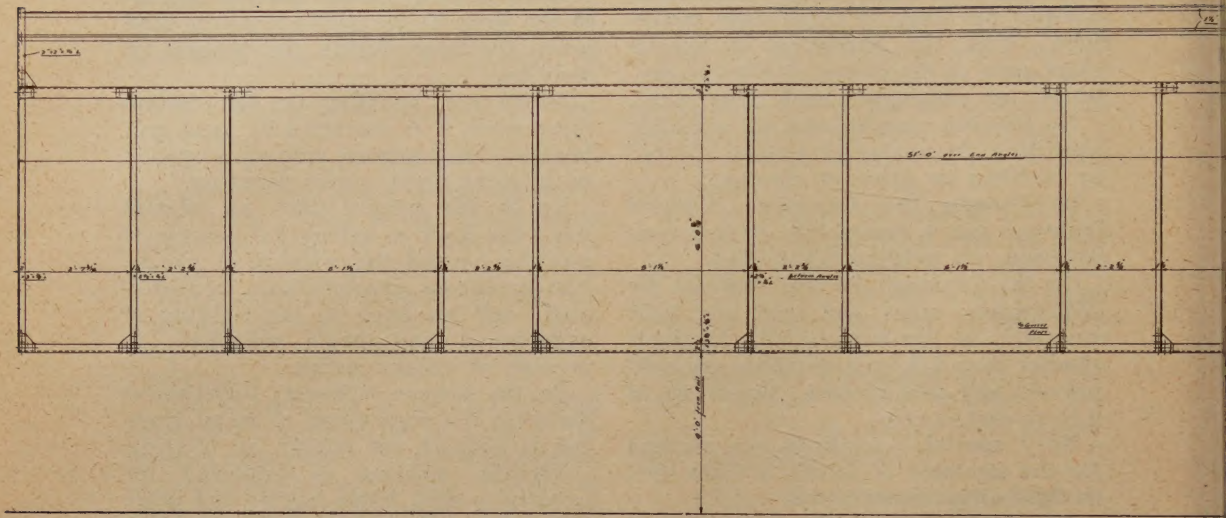
On the *South Manchuria* Railway riveting and electric welding are both used in the assembly of all-metal carriages. When welding is used, the joint is backed with a piece of copper plate in order to dispel the heat and prevent local deformation.

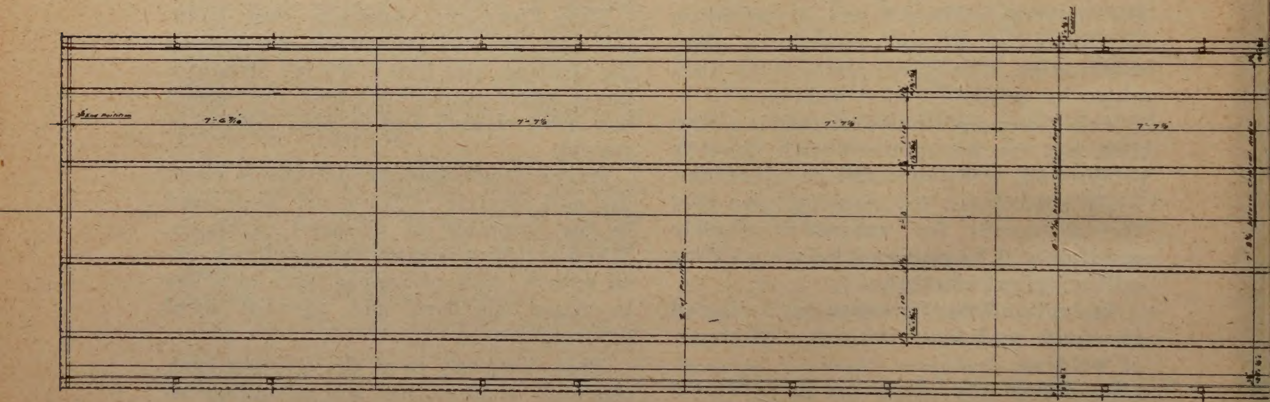
This Company is of the opinion that, although welding has the advantage of reducing the weight of the metal framing, further consideration is required before using welding for all joints.

With a view to facilitating painting and cleaning, welding is used for all joints on the exterior panels.

V. — Use of light metals and alloys.

The use of light metals in the main construction of rolling stock is still so





limited that no definite conclusions can be formulated upon the subject.

On the other hand, aluminium alloys are largely used for interior fittings, such as seat pedestals, parcel rack brackets, grab handles, etc., and have shewn economy, but where light alloys have been used in place of timber for such items as window frames, an increase in cost has been noted.

U. S. A. — Carriages constructed entirely in aluminium have been built by the Pennsylvania Railroad. Double deck cars, sections of which are shewn in figures 1 and 2, and standard electric cars have been so constructed. The reduction in weight which has been effected by comparison with a car built in steel is given as 40 %, but an increase in first cost of 20 % has resulted.

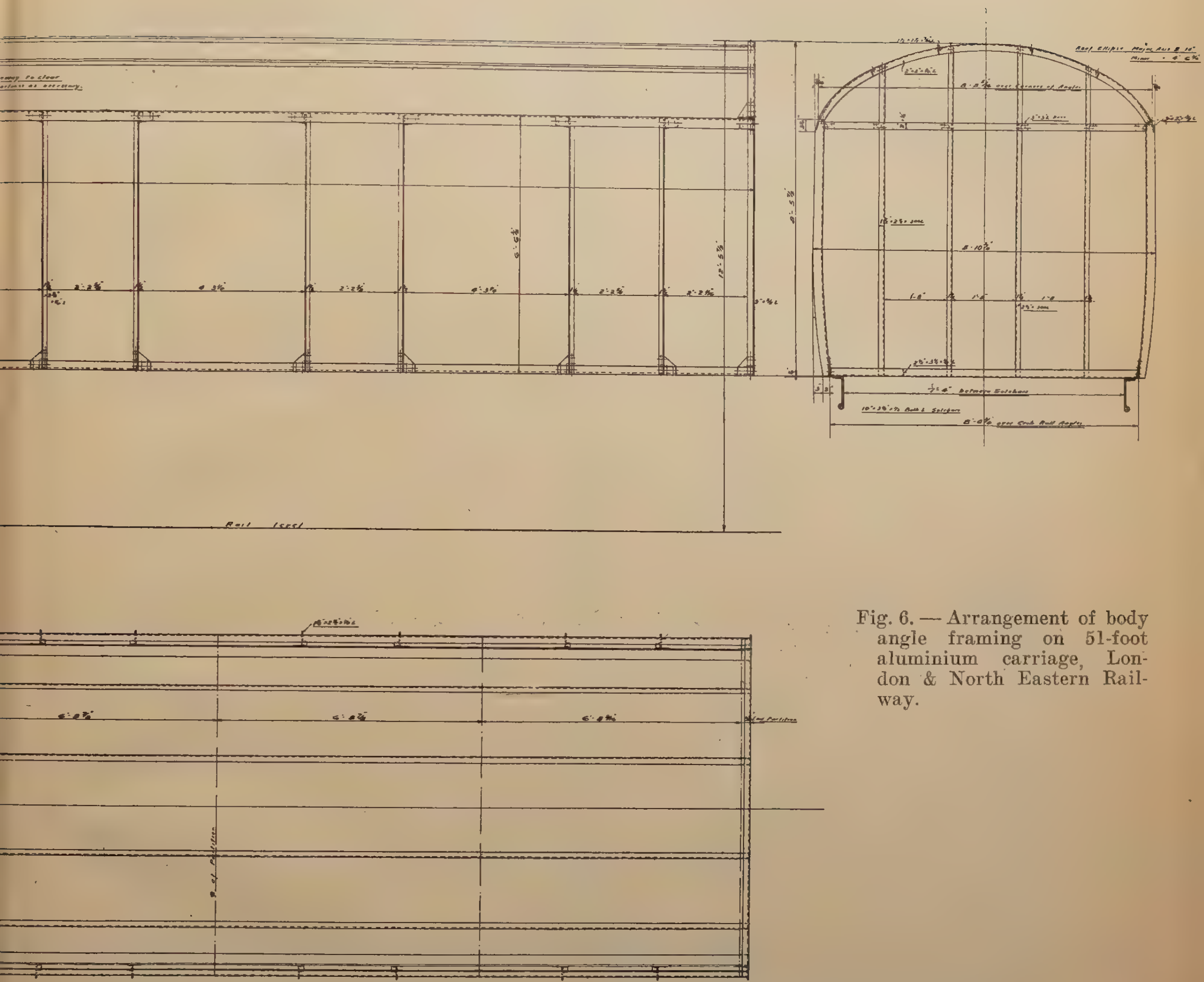


Fig. 6. — Arrangement of body angle framing on 51-foot aluminium carriage, London & North Eastern Railway.

The construction of multiple unit cars entirely in aluminium alloys is contemplated by the New York Central Railroad, but designs are not sufficiently far enough advanced to enable drawings or other data to be supplied.

The Reading Company have 70 multiple-unit electric cars under construction, embodying the use of aluminium alloys for such items as floor sheets, roofs, vestibule end sheets, body ends, and roof, side and end linings, as well as for interior fittings such as parcels racks. The saving in weight effected on one of these cars is 6 640 lb., with an increase in cost of 1 475 dollars.

The Baltimore and Ohio Railroad have built two trailer cars in which aluminium has been used for wainscoting, pier and frieze panels and ceilings. The

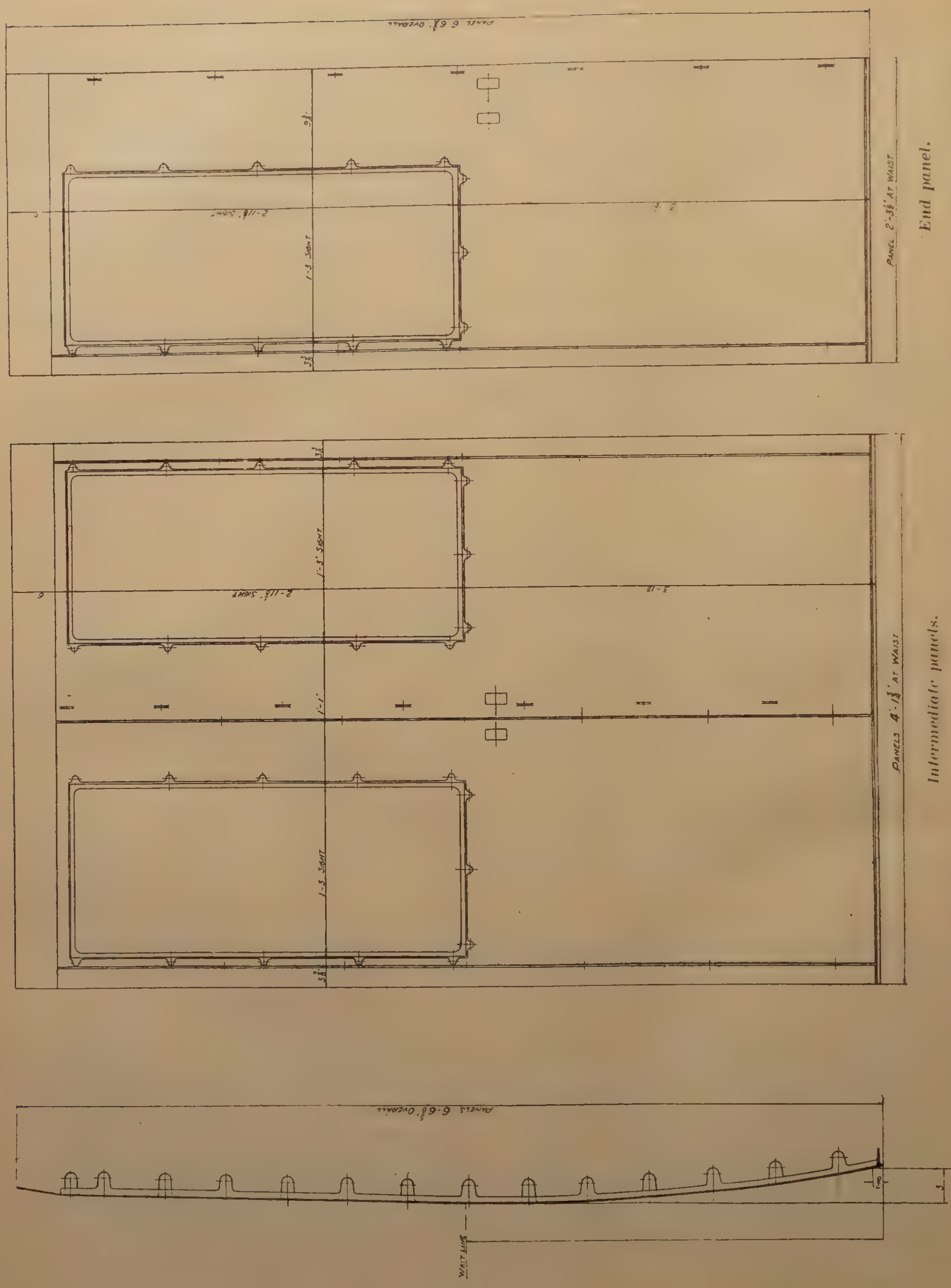


Fig. 7. — Details of body side panels (material : Alpax). of 51-foot aluminium carriage, London & North Eastern Railway.

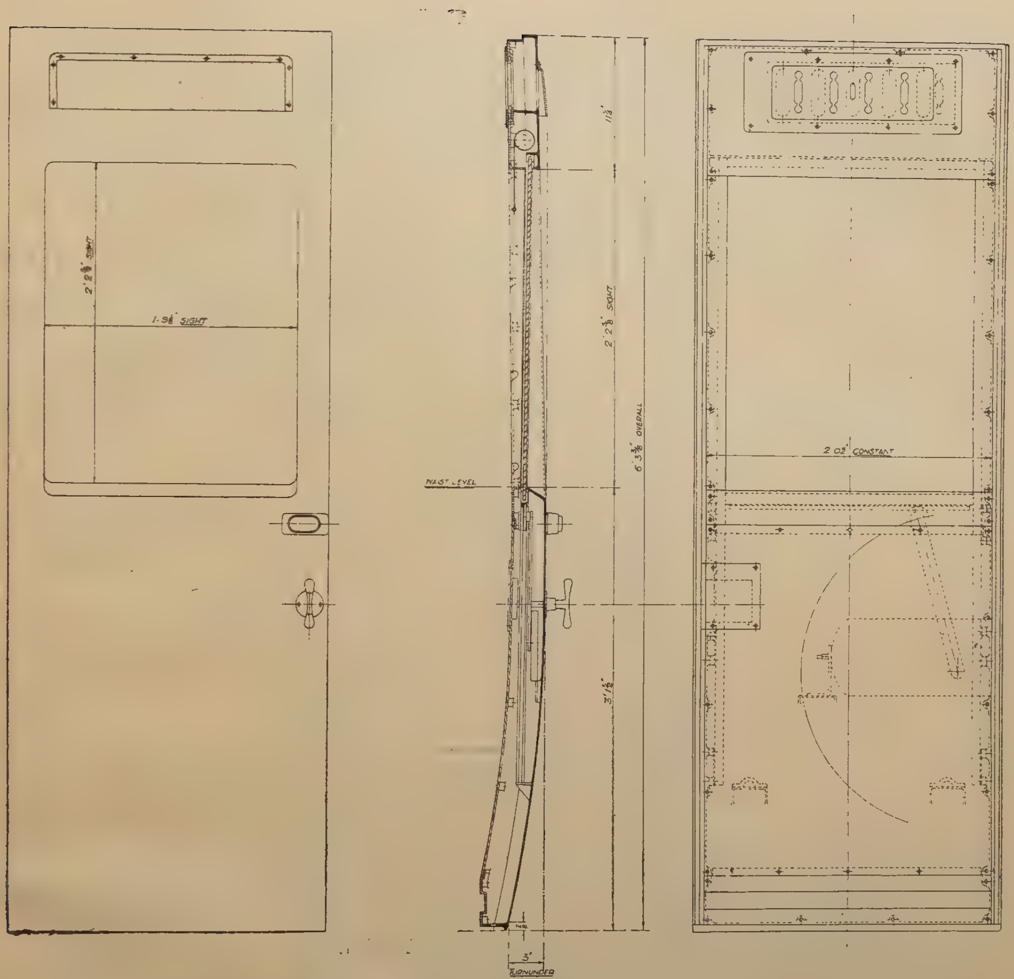


Fig. 8. — General arrangement of door (material : Alpax), of 51-foot aluminium carriage, London & North Eastern Railway.

aluminium alloy used contains from 8 % to 12 % of copper.

In *Great Britain,* the London and North Eastern Railway have decided to construct one carriage body of « Alpax » aluminium alloy, the sides, ends and doors being all alloy castings, suitably ribbed and strengthened, and riveted to steel framework forming pillars and cant rails. The roof will be of duralumin sheets carried on « Alpax » carlines, and it is anticipated that an eight per cent reduction in the weight of the vehicle will be effected. A general arrangement of the framing, and details of the side construction and of the doors, are shewn in figures 6, 7 and 8.

The London and North Eastern Railway use « Alpax » fittings in all classes of stock, and have recently introduced

steam heating couplers and vacuum brake couplers made of this metal.

On the London Midland and Scottish Railway, « Alpax » is used for fittings such as door drop lights and quarter light mouldings.

On the Metropolitain District and London Electric Railways, Alpax is being largely used for seat frames, seat handles, hand strap brackets, sundry interior fittings, and doors.

The composition of light alloys used by various railways differs considerably. The following table gives particulars of analyses and physical characteristics which have been furnished :

Name of alloy.	Chemical composition.	Physical characteristics.	
		Ultimate tensile strength, *tons per sq. inch.*	Elongation, *per cent, in 2 inches.*
N°. 12 aluminium (American)	Copper, 8 %. Aluminium — remainder.	9	1.5 %
Copper-tin alloy	Copper, 6 % to 8 %. Tin, up to 1 %. Aluminium — remainder.	9	3
Alpax	Silicon, 8 % to 15 %. Aluminium — remainder.	11 (sand cast). 13.5 (die cast).	8 % 12 %
Duralumin	Copper, between 3.5 % and 4.5 %. Manganese, between 0.4 %. and 0.7 %. Magnesium, between 0.4 %. and 0.7 %. Iron, not more than 0.5 %. Aluminium, 94.5 %.	25	15 %

The practice of the Gold Coast Government Railways, in *Africa,* with regard to existing types of carriages, is to use zinc for exterior panels and aluminium for the sunshades. Louvre frames and lavatory floors are « Alpax » castings, and lavatory walls are of sheet aluminium.

In *Australia,* the New South Wales Government Railways use aluminium-copper-tin alloy castings for both sliding and hinged doors.

When light metals and light alloys are used in conjunction with ferrous metals, precaution is necessary to prevent corrosion taking place. This generally consists of painting the jointing surfaces with red lead or other anti-corrosive paints. On the Baltimore and Ohio Railroad a layer of felt is placed between all joints of aluminium with steel, whilst on the Gold Coast Government Railways a piece of teak packing is used.

VI. — **Heat insulation.**

The replies reveal a wide divergence of practice, and it is apparent that the practice adopted depends upon the climate of the country.

In the *United States of America* and in *Canada* the general practice appears to be to apply sheets of three-ply « Salamander » insulation to the inside of the outer panels and two-ply insulation to the back of the interior panels. Figure 9 illustrates the practice on the Canadian Pacific Railway. «Salamander»

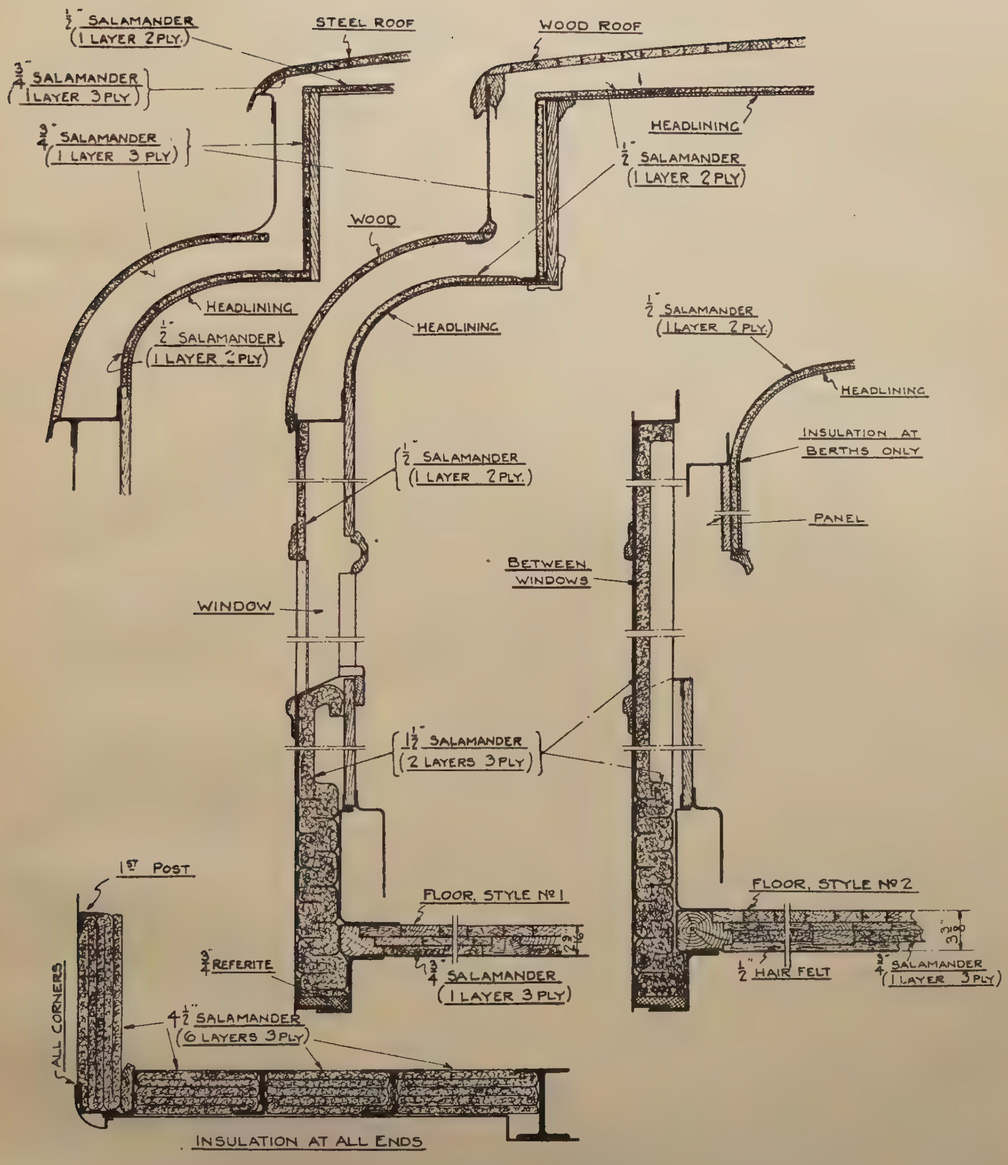


Fig. 9. — Passenger car insula ion, Canadian Pacific Railway.

is also used under the steel roof sheeting. The method of applying the insulation is to spotweld nails or cleats, which pass through the « Salamander », to the backs of the panels; thin washers are placed over the points of the nails which are then bent over.

In *Africa* sunshade panels are largely

used, in addition to which heat insulating sheets such as « Celotex » and « Sundeala » are applied to the back not only of the sunshade panels but also of the main panelling.

In *Japan*, and on the Korean (Chosen) Government Railways, and on the *South Manchuria* Railway, thick layers of hair felt are applied on the back of steel panels, and the inside finish is of wood. In some cases cork is used in place of felt.

In *England* it has not been found necessary to use any insulating material on the inside of the steel panelling, but between the interior wood casing and the outside panelling there is a continuous space which is open to the atmosphere along its bottom edge and through torpedo extractors at the top. This has been considered to be a sufficiently good non-conductor of heat to meet climatic variations.

It has not been found necessary to increase the area of the steam heating pipes in carriages constructed of steel.

From the foregoing it would appear that in climates where the temperature is generally mild no special means are necessary for heat insulation, but that in countries where extreme temperatures are experienced, non-conducting material must be attached to the interior of the steel panels and that in tropical countries, where the carriages are subject to direct radiant heat, sunshade panels must be fitted as an additional precaution.

VII. — General remarks.

The replies, when considered as a whole, show that no definite decision in favour of any particular form of construction can be made, the decision come to in each instance being influenced by local and climatic conditions, by the methods of operation and facilities for maintenance, and in certain cases by the practice of the countries controlling the railways.

The question of safety has in some cases been regarded as of primary importance and steel stock has been adopted in many instances for this reason. In view of the comparative freedom from accidents on railways, the question of safety should not solely decide the question. Other important factors must be considered, viz. :

1. The comfort and well-being of passengers.

2. First cost and cost of maintenance.

1. *Comfort of the passenger.*

The comfort of the passenger depends upon :

a) Smooth riding and quietness,

b) Upholstery, interior decorations and the amenities,

c) Adequate lighting, heating and ventilation.

None of these desiderata is enhanced by the use of all-metal stock, and as regards heating, ventilation and quietness, the advantage lies with the wood body.

2. *First cost and cost of maintenance.*

Comparisons which have been made between the first cost of all-steel carriages as compared with carriages having wooden bodies of an exactly similar type, indicate generally that the first cost of the all-metal carriage is greater than the cost of the wooden carriage, and if light alloys are used to any large extent in the construction, the cost will be still greater. On the other hand, it must not be forgotten that in the case of carriages built of light metal alloys the residual value is much greater.

No definite conclusion can be arrived at as to the comparative cost of maintenance, a sufficiently long period not having elapsed since the introduction of all-metal stock, but there is considerable apprehension that the costs of maintenance of all-steel stock will be greater than of similar stock constructed of

wood. The difference, however, will not be so greatly marked with stock which is subjected to a considerable amount of rough usage.

B. — Wagons.

I. — General considerations.

As regards wagons, the tendency is towards all-metal construction in spite of the difficulties experienced through corrosion. The reasons for this tendency are :

1. All-metal stock stands up better under the rough usage to which the stock is subjected.

2. The increasing difficulty in many countries in obtaining suitable timber at reasonable prices, especially as a result of the increase in size of the vehicles.

The replies reveal a movement towards standardisation of design for the usual types of wagons. The practice in Great Britain may be quoted as an example. In Great Britain, open goods and some other classes of wagons are in common use as between the four main line Companies. As a result of this, wagons built by any one Company circulate over and are used by the other Companies. Consequently the standardisation of the more usual types of wagon has been facilitated. The work of standardisation has been carried out by the Committee of Chief Mechanical Engineers at the Railway Clearing House. So far the following standard wagons have been designed :

12-ton open goods wagon.
12-ton covered goods wagon.
12-ton mineral wagon.
20-ton mineral wagon.

Of these only the 12-ton covered and 20-ton mineral are of all-metal construction.

The designs were based on the experience of the various railways with their own stock, and have resulted in well designed wagons which will give good results in service.

Drawings of these wagons are shewn as under :

12-ton covered goods wagon.

General arrangement . . . fig. 10
Underframe . . . . fig. 11

20-ton mineral wagon.

General arrangement and underframe . . . . fig. 12

The particular types of traffic for which wagons are used also has a great bearing on the policy adopted for construction.

In the *Argentine* it is the policy of all the railways to construct all new wagons entirely in metal.

The reasons which justify this policy are that the maintenance costs are less, and that steel wagons have a longer life and are less liable to damage. The Cordoba Central Railway also state that parts can be quickly replaced from stock, and the period in the shops under repair is reduced. Bulged plates and other metal parts can be straightened, and cracks electrically welded, thereby saving the expense of new materials.

In the *United States of America* the policy of constructing all new wagons entirely in metal has, with the exception of two railways, been generally adopted. This policy is justified by greater strength, less maintenance costs, longer life, safety of operation, and greater capacity.

The Delaware and Hudson Railroad favour composite construction for the following reasons : Lower maintenance costs. A large number of repairs can be made to composite wagons at other than main shops. Certain properties in coal cause corrosion in steel, but do not affect wood.

The Wabash Railway will construct all mineral wagons of the hopper type

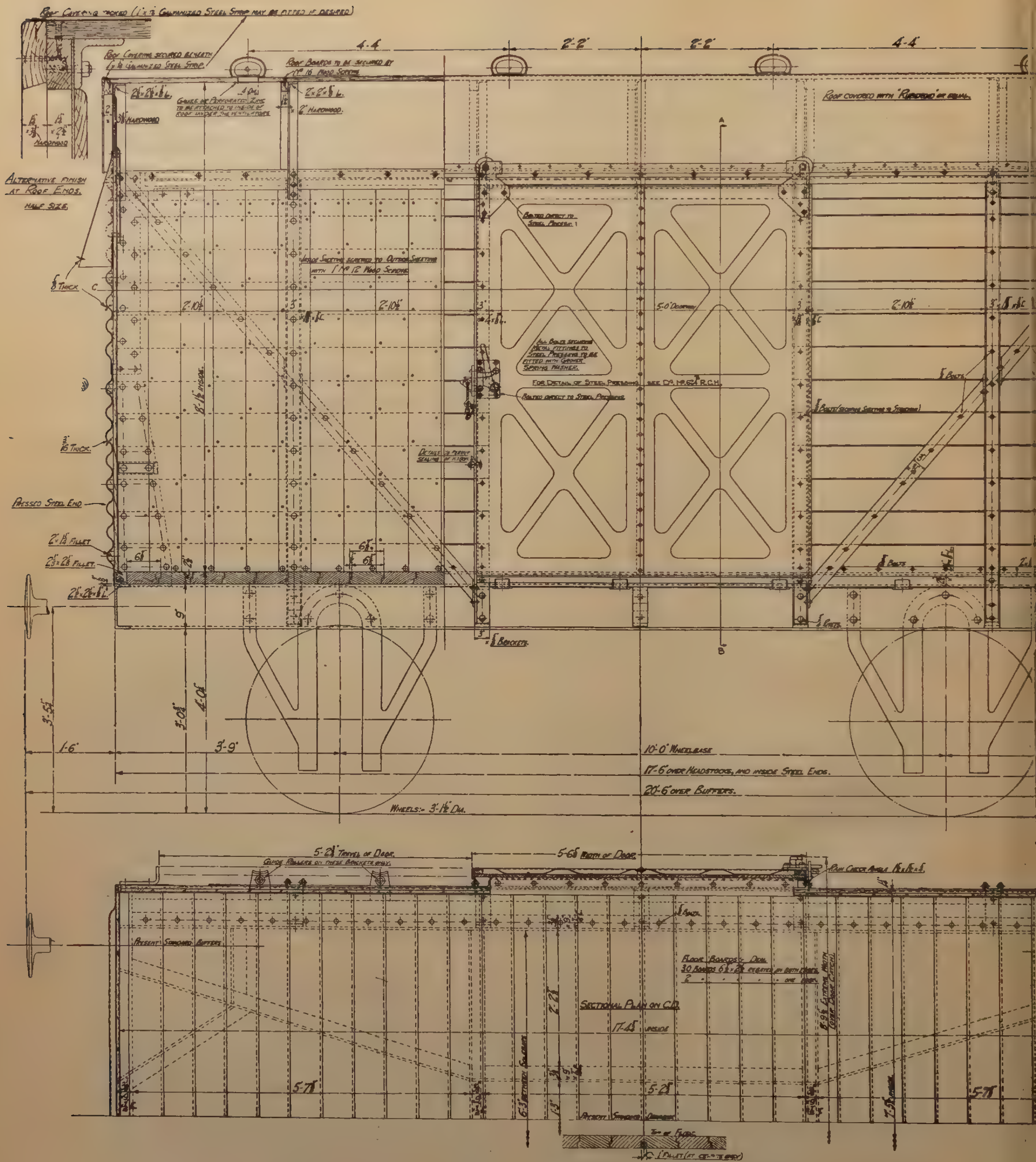
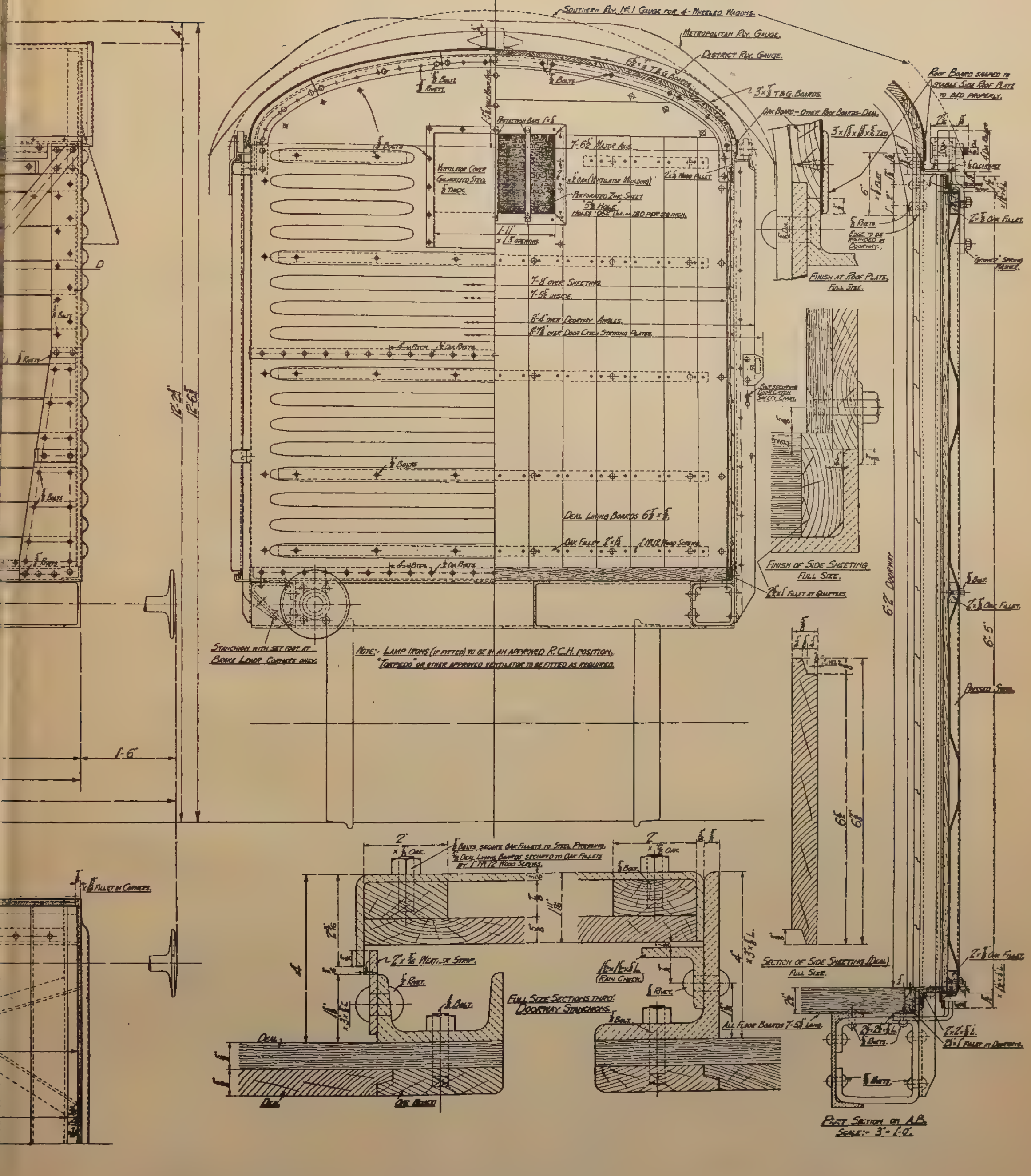


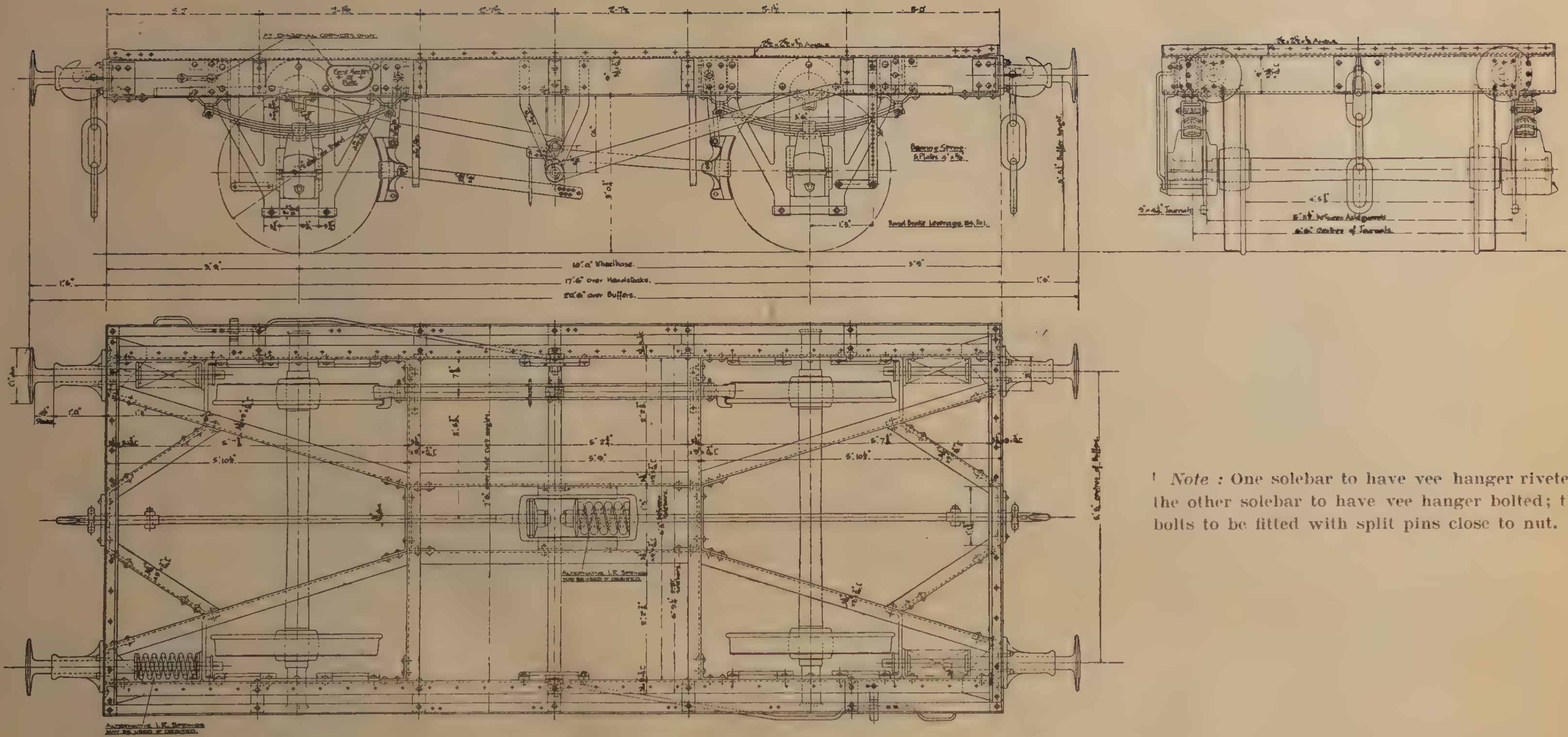
Fig. 10. — Arrangement of standardised 12-ton covered good

Capacity (to underside of r



n (unfitted), of the four British main line Companies.

les) = 993 cubic feet.



¹ *Note :* One solebar to have vee hanger riveted, the other solebar to have vee hanger bolted; the bolts to be fitted with split pins close to nut.

Fig. 11. — Standardised 12-ton covered goods wagon (unfitted), of the four British main line Companies. — Arrangement of metal underframe.

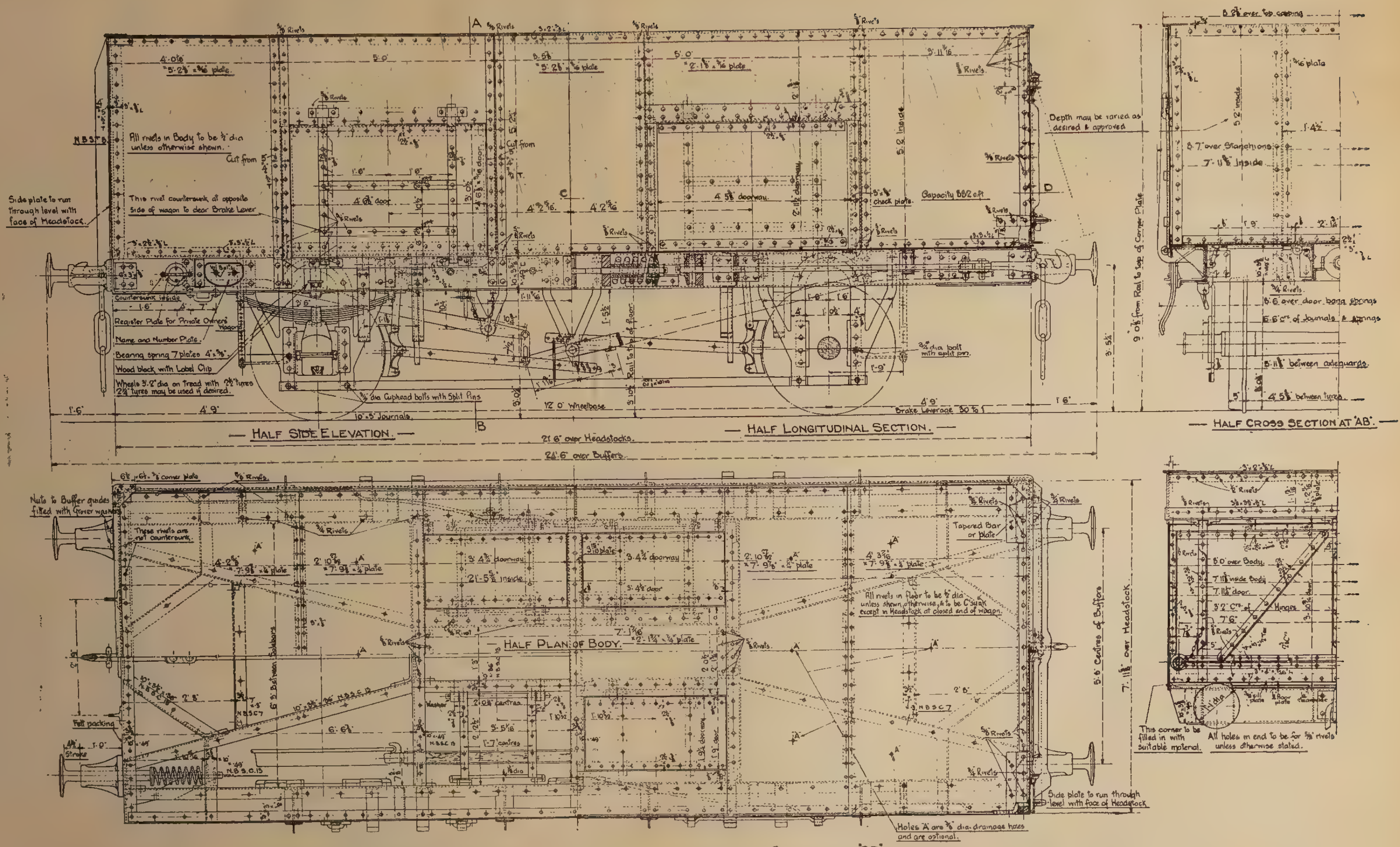
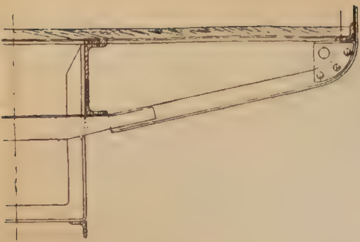


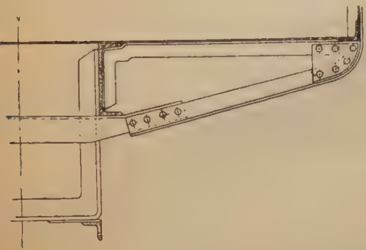
Fig. 12. — Standard 20-ton mineral wagon with metal body, of the four British main line Companies.



Argentine.

Buenos Ayres Western Railway.

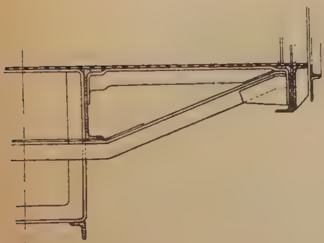
Rolled steel centre sill, angle side sill, and fixed angle trussing.
Pressed steel panel.



Argentine.

Central Argentine Railway.

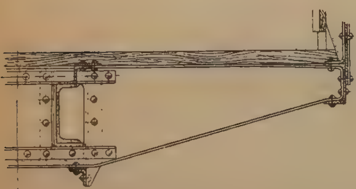
Rolled steel centre sill, angle side sill, and fixed angle trussing.
Pressed steel panel.



Argentine.

Cordoba Central Railway.

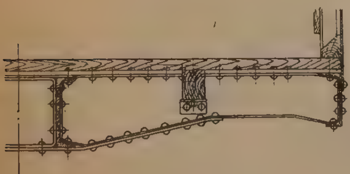
Rolled steel centre and side sills, and fixed angle trussing.
Pressed steel panels.



U. S. A.

Baltimore and Ohio Railroad.

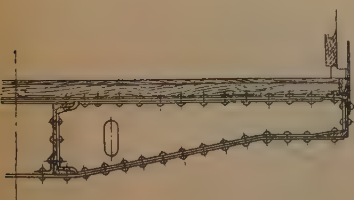
Rolled steel centre and side sills.
Pressed steel panels.



U. S. A.

New York Central Railroad.

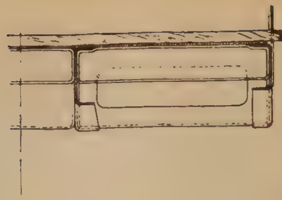
Rolled steel channel centre and side sill.
Steel panel.

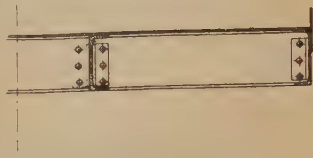


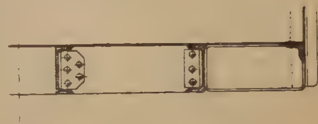
U. S. A.

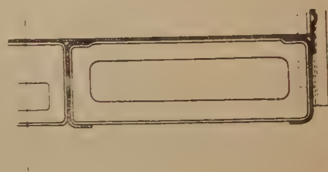
Norfolk and Western Railway.

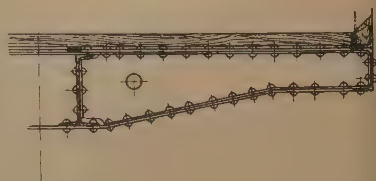
Rolled steel channel and angle centre sill, and channel side sill.
Steel panel.











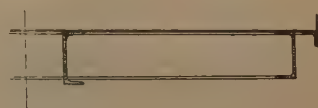


Fig. 13. — Types of underfran

ld Coast Government Railways.

l steel centre and side sills, and cross

panel.

Sudan Government Railways.

steel channel section solebars and itudinals.
panel.

Kenya and Uganda Railways.

steel channel section longitudes and and angle side sills.
panel.

Kenya and Uganda Railways.

l steel centre and side sills, and cross-s.
panel.

l.

Canadian National Railways.

d steel section centre and side sills.
ed steel crossbearers.

.a.

Canadian Pacific Railway.

d steel section centre and side sills.
sed steel crossbearers.
panel.

a.

Ceylon Government Railways.

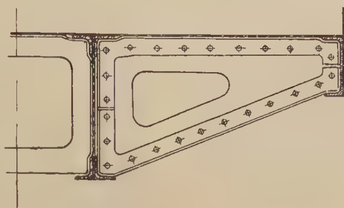
d steel centre and side sills.
panel.

covered merchandise wagons.

India.

Indian Railway Standards.
Bengal Nagpur Railway.

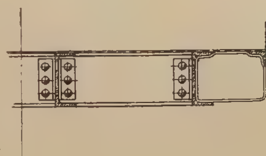
Rolled steel channel section solebars and longitudes, and angle side sills.
Steel panel.



India.

Indian Railway Standards.
Great Indian Peninsula Railway.

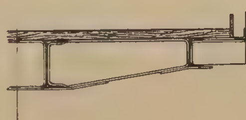
Plate web and four angle centre sill and rolled steel channel side sill.
Steel panel.



Malaya.

Federated Malay States Railways.

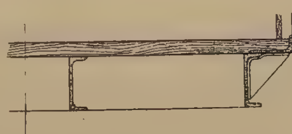
Rolled steel channel section solebars and longitudes, and angle side sills.
Steel panel.



Japan.

Japanese Government Railways.

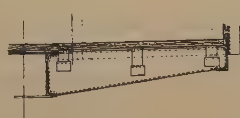
Rolled steel channel section solebars and longitudes, and angle side sills.
Steel panel.



Great Britain.

London Midland and Scottish Railway.

Rolled steel channel section solebar and longitudinal, and angle side sill.
Steel panel.



China.

South Manchuria Railway.

Rolled steel channel section solebar and longitudinal.
Steel panel.

in metal, because of reduced maintenance costs.

Canada. — The Canadian National Railways will only develop the construction of metal wagons to a limited extent. A composite type of wagon in wood and steel is favoured as this utilises the material most common in the country.

With the exception of flooring and lining, the Canadian Pacific Railway will construct all new wagons in metal, as traffic conditions require wagons of ample strength for movement in heavy main line trains at increasing speeds.

In *Great Britain* the construction of metal wagons will be developed to a limited extent only.

On the Great Western Railway the practice in regard to open goods wagons is to make the floor and sides of timber, carried on an iron or steel underframe. Wooden bodies are preferred to steel ones by the Goods Department.

The London Midland and Scottish Railway are still carrying out experiments, but have not yet sufficient information as to costs, etc., to decide what their policy is to be.

The London and North Eastern Railway will construct metal wagons to a limited extent according to the materials to be carried. This policy is influenced by the fact that most of the Company's shops are laid out to deal with the building and repairing of timber-constructed wagons.

Australasia. — The New South Wales Government Railways will construct, with the exception of floors, all open, flat, and mineral wagons, entirely of steel. The underframes and body framing of cattle, sheep and louvred vans will be of steel. This policy is justified by reduced maintenance costs.

The policy of the New Zealand Government Railways is to construct all new open wagons entirely in metal.

For the class of goods for which these wagons are used, it has been found that all-steel construction is more suitable and the cost of maintenance less than those previously built of wood.

Africa. — Opinion in this Continent is divided.

The Gold Coast Government Railways will construct all-metal wagons to a limited extent only.

The Kenya and Uganda Railways will construct all new wagons in metal, with the exception of cattle wagons and cold storage cars.

All-metal wagons were originally used by this Railway and have proved satisfactory, therefore no change in policy is contemplated.

The Nigerian Railways will construct all-metal wagons for certain traffic only. The workshops are better equipped to deal with repairs to wood-bodied stock. Steel-bodied vehicles for certain classes of traffic are subject to corrosion and are expensive to maintain.

On the Sudan Government Railways it is the policy to construct all new wagons entirely in metal, as steel wagons withstand the climate and rough usage better.

In *India* it is the policy of all the Railways to develop the construction of all new wagons in metal.

The East Indian Railway state that the life of a mild steel wagon in this country is approximately 33 % longer than one constructed of timber, and maintenance charges are considerably less.

On the Bengal Nagpur Railway, all-metal wagons have proved satisfactory in service, and are less expensive to maintain than wood or part steel and wood wagons.

In *Ceylon* the construction of all new wagons in metal will be developed on account of the decreased first cost and maintenance charges.

Malaya. — The Federated Malay States Railways state that with the exception of certain types for which timber is

considered to be more suitable, it is their policy to develop the construction of all-metal wagons.

The reasons which justify this policy are :

Steel underframes are superior to wood in withstanding excessive draw and buffing shocks. Galvanised iron or steel plate is used for the construction of the bodies, and is found to withstand the corrosive effect of the climate better. At the same time such a body requires less attention than one of timber.

Japan. — With the exception of the roofing of box wagons and the drop sides of open wagons, the policy of constructing all new wagons in metal will be developed by the Japanese Government Railways. The reasons given for using timber in the construction of wagons are as follows :

For safety and protection against rain leakage in the case of box wagons. Wood boards are used for the roofing of box wagons to prevent the accumulation of heat inside, and for drop sides of open wagons (gondolas), where rain leakage is not feared and stiffness is required.

Korea. — The Korean (Chosen) Government Railways have not any fixed policy at present regarding the construction of all-metal wagons, but experiments are being carried out with some wagons made entirely in steel. The durability of metal parts, especially steel plates, is not yet confirmed.

Manchuria. — The policy of constructing all new wagons in metal will be developed by the South Manchuria Railway. This policy has been decided upon on account of solidity, strength, durability and less liability to damage from fire and water.

II. — Percentages of types of metal construction.

These figures, in the absence of similar figures for 1930, do not permit of any comparison to be made as regards the growth of all-metal stock. They indicate the extensive use of stock of such construction, and also the wide variations in practice as between different parts of the world.

III. — General principles underlying construction.

The replies reveal no universally adopted standard practice as regards the construction of the frames of wagons.

The design is largely governed by traffic requirements and also by standard practice as regards draw and buffer gear.

Cross sections of the underframes of covered goods wagons used by the various railways are shewn in figure 13.

A general survey of the designs of all-metal wagons on the various Railways is given below :

Argentine. — The Buenos Ayres Western Railway use « Livesey Gould » underframes built up of rolled sections, but a few open wagons and hopper wagons are constructed with pressed steel underframes and bodies.

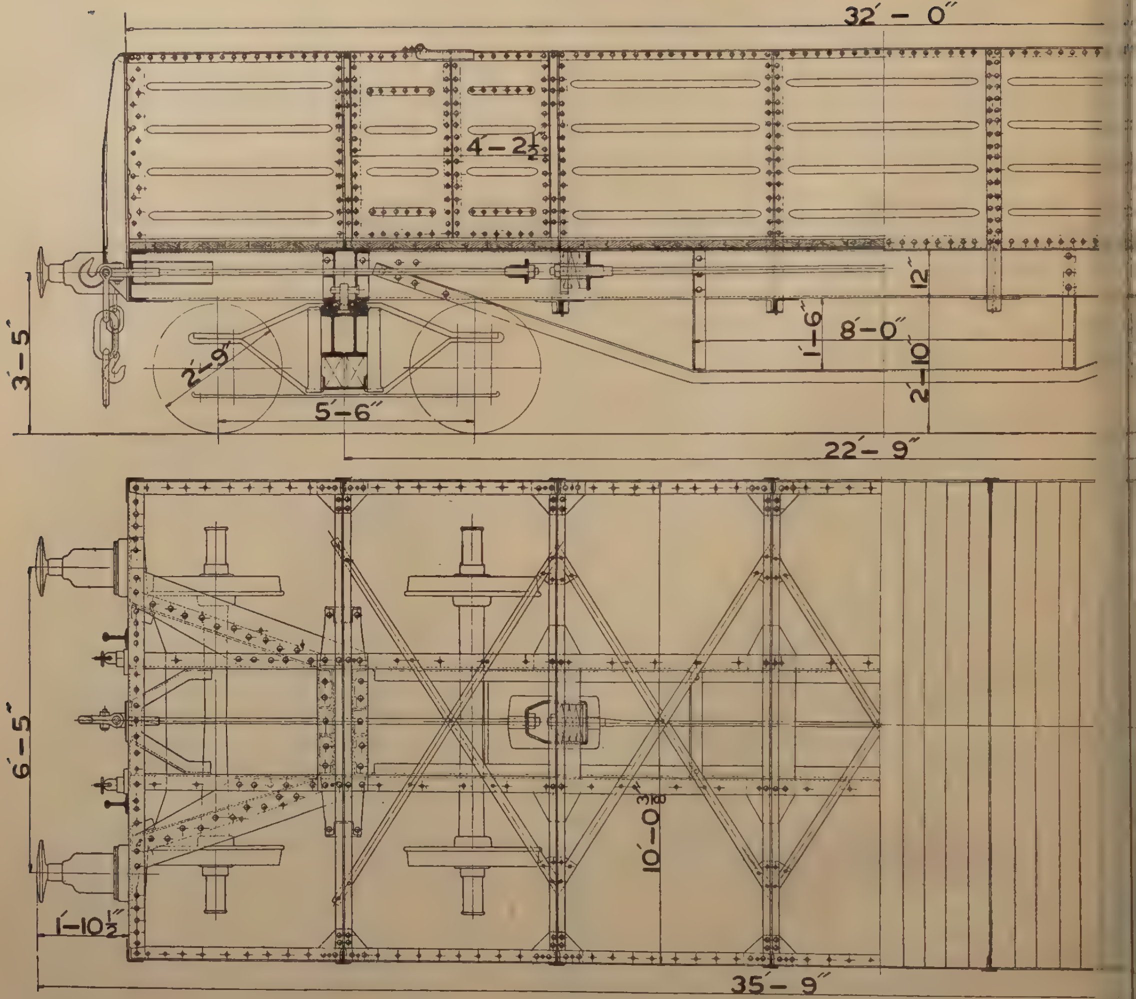
An open wagon with « Livesey Gould » underframe is shewn in figure 14.

On the Central Argentine Railway, the body and underframe of low sided open wagons are treated as one structure, and follow the usual practice of wagons fitted with side buffers. Open wagons with high sides are constructed with heavy centre sills.

For covered wagons the body is built up on the normal type of underframe suited to side buffing, and is fitted with a roof of galvanised sheets.

On the Buenos Ayres and Pacific Railway, the underframes of covered goods wagons of 35-ton capacity are built up of rolled steel sections, etc., and have deep centre sills. The body pillars are « Tee » sections, and the outside panels are pressings in 5/64-inch steel plates.

35-ton hoppered ballast wagons are



constructed with channel section side sills, the other members being of various rolled sections pressings and plates.

The Cordoba Central Railway have no all-metal open merchandise wagons. Covered wagons of 35-ton capacity are fitted with diamond frame bogies, and an underframe built up of rolled steel sections, etc., with deep centre sills. Rolled steel « Tee » section is used for the body pillars, and pressings of 5/64-inch steel plate are used for outside panels. The roof is of No. 20 B.W.G. corrugated iron sheeting.

35-ton bogie hopper ballast wagons are constructed with channel-section side sills to carry the load, other members being of various rolled steel sections, pressings and plates.

United States of America. — The Bal-

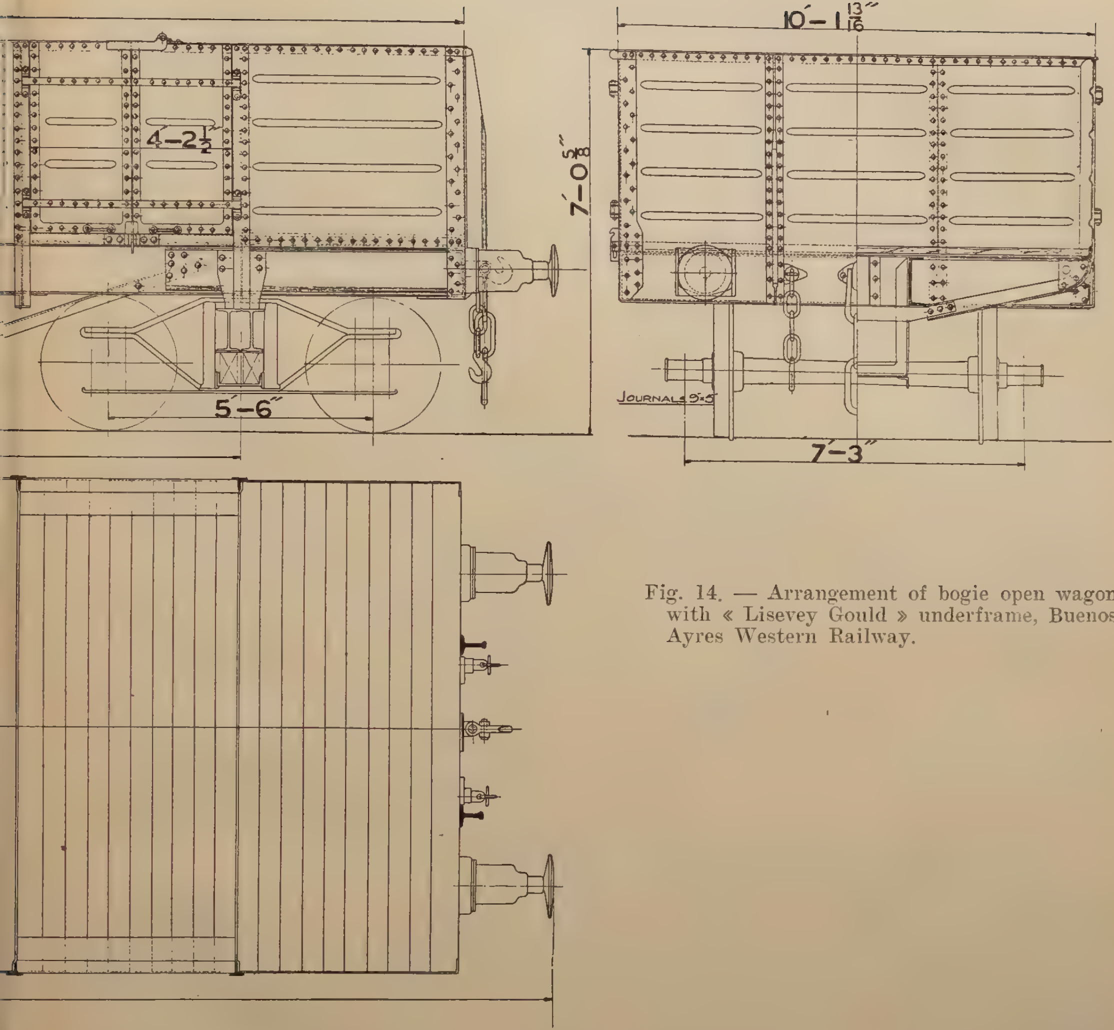


Fig. 14. — Arrangement of bogie open wagon with « Lisevey Gould » underframe, Buenos Ayres Western Railway.

timore and Ohio Railroad reply that the general principle underlying the construction of their all-metal wagons is :

To make wagons that will withstand the severe punishment to which they are subjected.

Moreover the maintenance costs of all-metal wagons are less than with wood or composite wagons.

Figure 15 shows the form of end construction used by this railway on hoppered mineral wagons.

On the Delaware and Hudson Company, hopper wagons of 55-ton capacity are of the side-carrying type, and are built up of rolled steel sections, pressings and plates.

On the New York Central Railroad, open wagons are of side-carrying construction, excepting high-capacity gon-

The following table shows the percentage of wagons constructed to the undermentioned headings.

<table>
<tr><th rowspan="2">NAME OF RAILWAY COMPANY.</th><th colspan="3">Entirely of metal.</th><th colspan="3">Underframe and body framing only of metal.</th></tr>
<tr><th>Open merchandise.</th><th>Mineral.</th><th>Covered merchandise.</th><th>Open merchandise.</th><th>Mineral.</th><th>Covered merchandise.</th></tr>
<tr><td>Buenos Ayres & Pacific</td><td>41.45 %</td><td>86.75 %</td><td>14.58 %</td><td>37.32 %</td><td>13.25 %</td><td>2.91 %</td></tr>
<tr><td>Buenos Ayres Western</td><td>83 % High-sided.
0 % Low-sided.</td><td>100 %</td><td>41 %</td><td>17 % High-sided
100 % Low-sided.</td><td>Nil.</td><td>49 %</td></tr>
<tr><td>Central Argentine</td><td colspan="2">65 %</td><td>43 %</td><td>...</td><td>...</td><td>10 %</td></tr>
<tr><td>Cordoba Central</td><td>Nil.</td><td colspan="2">12 1/2 %</td><td>100 %</td><td colspan="2">87 1/2 %</td></tr>
<tr><td>Baltimore and Ohio</td><td colspan="3">38 %</td><td colspan="3">24 %</td></tr>
<tr><td>Delaware and Hudson</td><td>Nil.</td><td>9.66 %</td><td>Nil.</td><td>Nil.</td><td>54.8 %</td><td>12.8 %</td></tr>
<tr><td>New York Central</td><td colspan="3">59.9 %</td><td colspan="3">4.2 %</td></tr>
<tr><td>Norfolk and Western</td><td colspan="3">95 %</td><td colspan="3">5 %</td></tr>
<tr><td>Pennsylvania</td><td>58 %</td><td>100 %</td><td>50 %</td><td>42 %</td><td>Nil.</td><td>50 %</td></tr>
<tr><td>Reading Company</td><td>62 %</td><td>100 %</td><td>21 %</td><td>38 %</td><td>Nil.</td><td>79 %</td></tr>
<tr><td>Wabash</td><td>Nil.</td><td>100 %</td><td>Nil.</td><td>50 %</td><td>Nil.</td><td>51 %</td></tr>
<tr><td>Great Western</td><td>...</td><td>79 %</td><td>26 %</td><td>96 %</td><td>...</td><td>37 %</td></tr>
<tr><td>London and North Eastern</td><td>0.67 %</td><td>2.11 %</td><td>Nil.</td><td>17.97 %</td><td>2.06 %</td><td>12.18 %</td></tr>
<tr><td>Gold Coast Government</td><td>46.4 %</td><td>37.7 %</td><td>57.5 %</td><td>12.3 %</td><td>62.3 %</td><td>30.6 %</td></tr>
<tr><td>Kenya and Uganda</td><td colspan="2">100 %</td><td>95 %</td><td colspan="2">Nil.</td><td>5 %</td></tr>
<tr><td>Nigerian</td><td>7.9 %</td><td>10.7 %</td><td>11 3 %</td><td>6.8 %</td><td>31 %</td><td>32.3 %</td></tr>
<tr><td>Sudan Government</td><td>100 %</td><td>100 %</td><td>93 %</td><td colspan="2">Nil.</td><td>7 %</td></tr>
<tr><td>New South Wales Government</td><td>83 %</td><td>51 %</td><td>Nil.</td><td>...</td><td>49 %</td><td>...</td></tr>
<tr><td>New Zealand Government</td><td>34 %</td><td>Nil.</td><td>Nil.</td><td>...</td><td>...</td><td>...</td></tr>
<tr><td>Canadian National</td><td>22.77 %</td><td>100 %</td><td>0.2 %</td><td>42.43 %</td><td>Nil.</td><td>62.64 %</td></tr>
<tr><td>Canadian Pacific</td><td colspan="3">17 %</td><td colspan="3">40 %</td></tr>
<tr><td>Ceylon Government</td><td>23 %</td><td>...</td><td>42 %</td><td>71 %</td><td>..</td><td>31 %</td></tr>
<tr><td>Bengal Nagpur</td><td colspan="3">98 %</td><td>Nil.</td><td>Nil.</td><td>Nil.</td></tr>
<tr><td>Eastern Bengal</td><td colspan="3">All wagons built in recent years.</td><td>...</td><td>...</td><td>...</td></tr>
<tr><td>East Indian</td><td colspan="3">99 %</td><td colspan="3">1 %</td></tr>
<tr><td>Great Indian Peninsula</td><td colspan="3">100 %</td><td>Nil.</td><td>Nil.</td><td>Nil.</td></tr>
<tr><td>Madras & Southern Mahratta</td><td colspan="3">100 %</td><td>Nil.</td><td>Nil.</td><td>Nil.</td></tr>
<tr><td>Federated Malay States</td><td>37 %</td><td>36 %</td><td>86 %</td><td colspan="3">2.6 %</td></tr>
<tr><td>Japanese Government</td><td colspan="3">10.1 %</td><td colspan="3">38.1 %</td></tr>
<tr><td>Korean (Chosen) Government</td><td colspan="3">1.3 %</td><td>12.4 %</td><td>...</td><td>5.7 %</td></tr>
<tr><td>South Manchuria Railway</td><td colspan="3">1 926 wagons.</td><td colspan="3">2 469 wagons.</td></tr>
</table>

dola wagons equipped with medium-height sides and fish-belly centre sills, which are of the side and centre-carrying type.

Both covered and mineral wagons are of side-carrying construction.

On the Pennsylvania Railroad the body and underframe are treated as or structure. On the Reading Company tl body and underframe are built as on unit, with heavy centre sills.

All-metal wagons on the Wabash Railway are built up of steel plates and shapes, and have heavy centre sills.

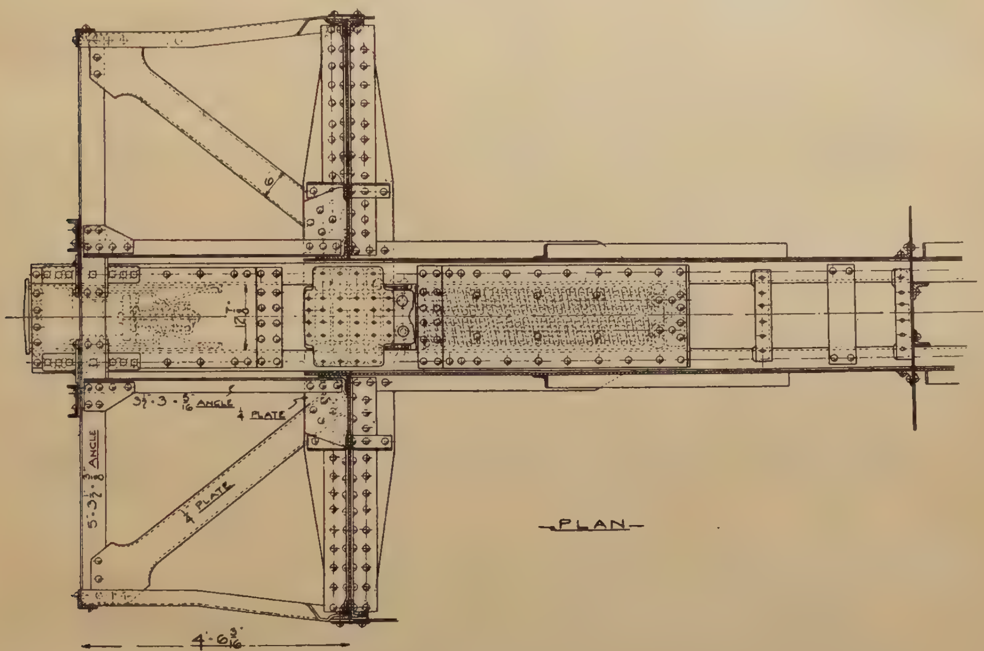


Fig. 15. — Arrangement of end of underframe on hoppered mineral wagons, Baltimore and Ohio Railroad.

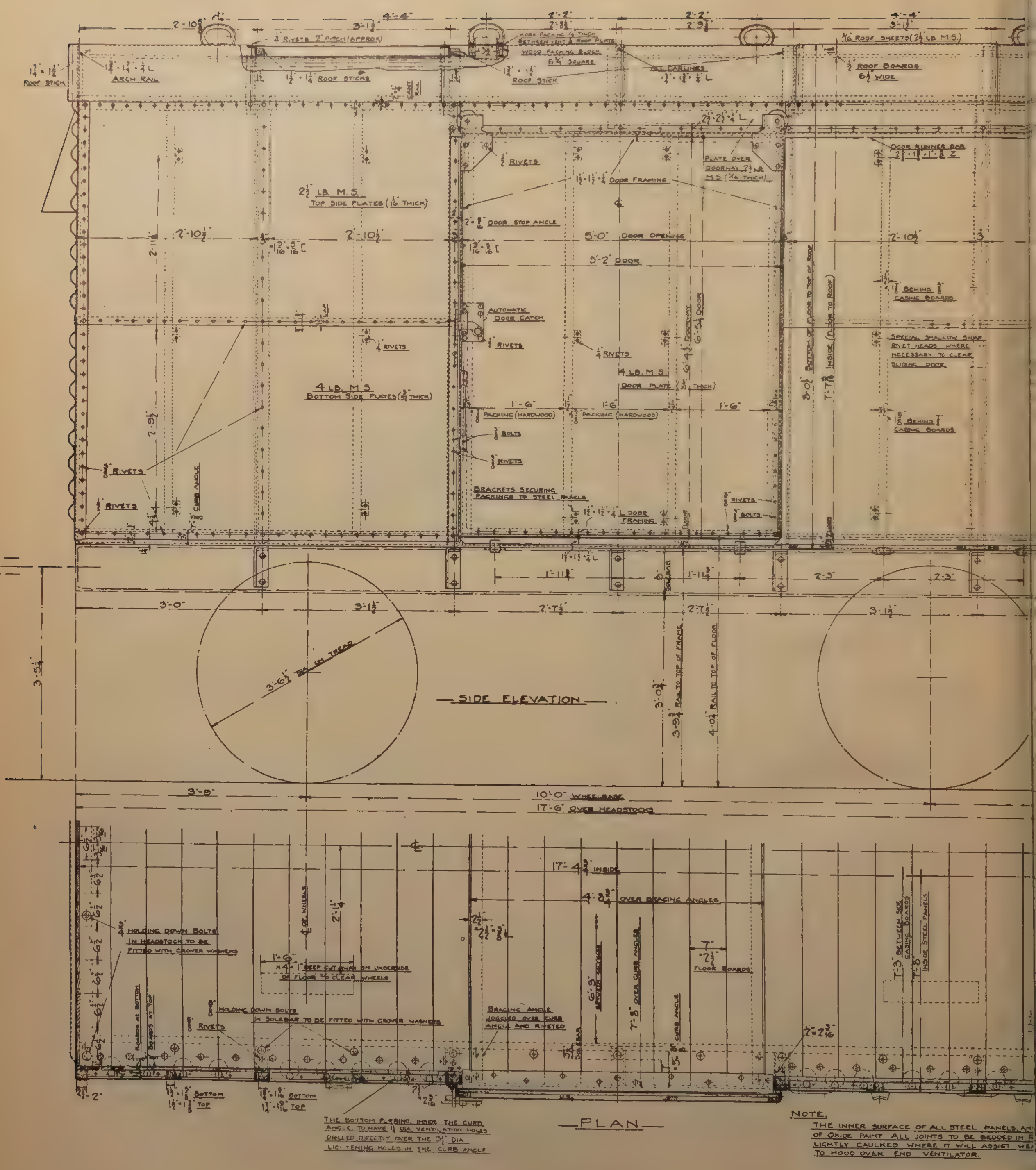
Canada. — On the Canadian National Railways the underframe has heavy centre sills, and with the body forms a single structure.

On the Canadian Pacific Railway all-steel wagons are constructed with heavy centre sills, which provide for buffing and drawgear stresses. The sides of the wagon act as load-carrying trusses, floor members transmitting the load to the sides.

Great Britain. — On the Great Western Railway the body and underframe are treated as one structure.

On the London Midland and Scottish Railway open wagons have underframes built up of rolled steel channels, angles and plates, also a few minor pressings where they can be conveniently and economically used. Covered wagons are constructed as above, but with outside steel body construction, and the interior lined with wood, this wagon being shewn in figure 16. Mineral wagons of 20-ton capacity and upwards are of all-steel construction, but are of an old type.

On the London and North Eastern Railway all-metal wagons are construc-



SIDE ELEVATION
PLAN
$2\frac{1}{2}$ LB. M.S. TOP SIDE PLATES ($\frac{1}{16}$ THICK)
4 LB. M.S. BOTTOM SIDE PLATES ($\frac{3}{32}$ THICK)
5'-0" DOOR OPENING
5'-2" DOOR
4 LB. M.S. DOOR PLATE ($\frac{3}{32}$ THICK)
AUTOMATIC DOOR CATCH
ARCH RAIL
ROOF STICK
ROOF BOARDS $6\frac{1}{2}$ WIDE
DOOR FRAMING
DOOR STOP ANGLE
PACKING (HARDWOOD)
BRACKETS SECURING PACKINGS TO STEEL PANELS
RIVETS
BOLTS
CURB ANGLE
SOLEBAR
$3'$-$6\frac{1}{2}$" DIA ON TREAD
RAIL TO TOP OF FRAME
RAIL TO TOP OF FLOOR
10'-0" WHEELBASE
17'-6" OVER HEADSTOCKS
17'-$4\frac{3}{4}$" INSIDE
4'-$8\frac{3}{4}$" OVER BRACING ANGLES
HOLDING DOWN BOLTS IN HEADSTOCK TO BE FITTED WITH GROVER WASHERS
HOLDING DOWN BOLTS IN SOLEBAR TO BE FITTED WITH GROVER WASHERS
DEEP CUT AWAY ON UNDERSIDE OF FLOOR TO CLEAR WHEELS
BRACING ANGLE JOGGLED OVER CURB ANGLE AND RIVETED
FLOOR BOARDS
SPECIAL SHALLOW SNAP RIVET HEADS WHERE NECESSARY TO CLEAR SLIDING DOOR
BEHIND CASING BOARDS
DOOR RUNNER BAR
THE BOTTOM FLOORING INSIDE THE CURB ANGLE TO HAVE $1\frac{1}{2}$ DIA VENTILATION HOLES DRILLED DIRECTLY OVER THE $3\frac{1}{2}$" DIA LIGHTENING HOLES IN THE CURB ANGLE
NOTE.
THE INNER SURFACE OF ALL STEEL PANELS, AN
OF OXIDE PAINT ALL JOINTS TO BE BEDDED IN
LIGHTLY CAULKED WHERE IT WILL ASSIST WE
TO HOOD OVER END VENTILATOR

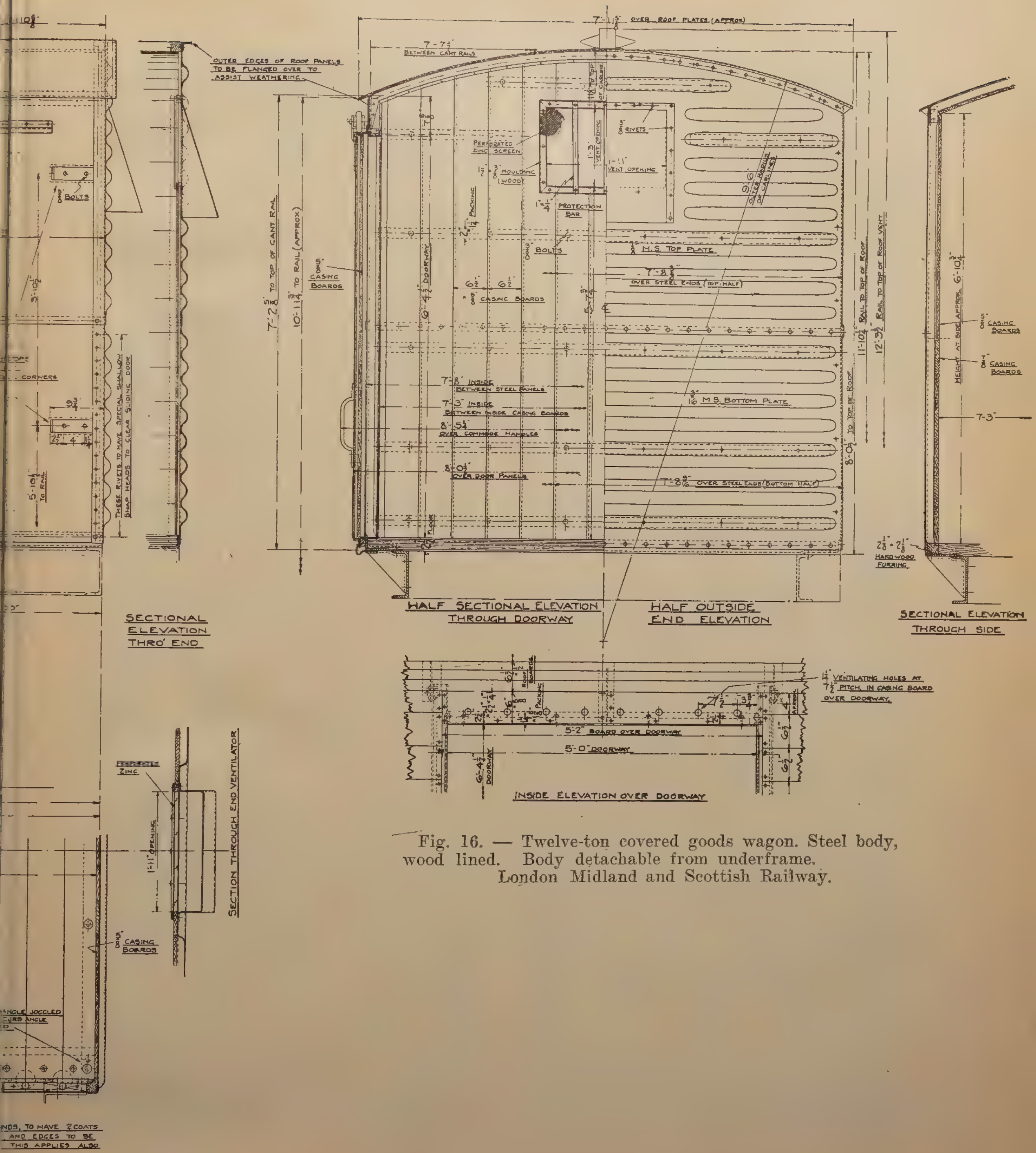


Fig. 16. — Twelve-ton covered goods wagon. Steel body, wood lined. Body detachable from underframe.
London Midland and Scottish Railway.

ted with the underframe designed to carry the load and take all the buffing and draw stresses.

Africa. — On the Gold Coast Government Railways open wagons of the bogie type have fish-belly underframes built up of steel pressings, etc. The sides of the body are also pressings, and plates, and are hinged to the underframe. A wood floor of 2-inch boards is bolted direct to the underframe.

Covered wagons are similar in construction to the open wagons, but have sides of pressed steel plates, and roofs of galvanised iron sheets.

On the Kenya and Uganda Railways four-wheeled open and covered wagons are built up with underframe and body as one structure, the centre sills being of heavy section at the ends to take the buffing and draw stresses. On bogie wagons a fish-belly type of underframe with pressed steel main members is used and as in the four-wheeled wagons the ends are strengthened for buffing and draw shocks.

On the Nigerian Government Railways, all the wagons are of the bogie type. The bodies are constructed of steel plates, either galvanised or pressed steel, and are riveted to the underframe, which is built up of rolled steel sections, and is fitted with longitudinal trussing.

On the Sudan Government Railways both open and mineral wagons have the body and underframe constructed as one unit. The underframe is of standard rolled steel sections, and in the case of bogie wagons is fitted with adjustable truss rods. Covered wagons are similar in construction to the above, but have roofs of corrugated galvanised sheets (No. 19 S.W.G.), the floor being of sheet steel.

Australasia. — In the construction of open and covered wagons, the New South Wales Government Railways combine the underframe and body framing in one structure.

On the New Zealand Government Railways, the underframes of open wagons are constructed of rolled steel channel sections, and the bodies are of rolled steel plates and angles, the whole assembly forming one structure; this wagon is shewn in figure 17.

Ceylon. — On the Ceylon Government Railways both open and covered wagons are constructed with underframes built up of standard rolled sections, channels, etc. On new bogie wagons the underframe trussing is of rolled steel angle section and is not adjustable. The body frames are of rolled steel angles, and the outside sheeting is of galvanised iron, or in the case of covered wagons, of steel. Side buffers are fitted.

India. — Wagons used on the Indian Railways are constructed to the standards of the Indian Railway Board.

On the Bengal Nagpur Railway, both open and covered wagons are constructed with the body and underframe as one unit, and are entirely of steel. Standard rolled steel sections and steel plates are used throughout. Mineral (bogie hopper ore) wagons are built up of rolled steel sections and plates, the body and underframe forming one structure. The outer members are girders with cross and inner longitude bearers.

On the Eastern Bengal Railway, in both open and covered all-metal wagons, the underframe is of box formation. The side and end panels of the body are riveted to the body stanchions, which in turn are riveted to the underframe.

With regard to mineral wagons, the underframes are constructed as above and the body (a shell) is riveted to a cradle.

On the East Indian Railway the underframes conform very closely to English practice, and are built up of rolled steel sections, etc. The bodies are built up of mild steel angles, plates and strips, and are constructed as one unit with the underframe.

On the Great Indian Peninsula Railway fish-belly underframes with heavy centre sills are used, and are constructed of rolled steel sections. The body framing is of rolled steel angles with steel side sheeting, and steel sheet or corrugated iron roof.

On the Madras and Southern Mahratta Railway all wagons are built to the designs of the Indian Railway Standards.

Malaya. — On the Federated Malay States Railways both open and covered wagons are built as single structures. The four main longitudinal members of the underframe are 9-inch × 3 1/2-inch channels sections of rolled steel, the ends being stiffened up to take the buffing and drawgear stresses.

Japan. — Various types of composite wagons are in use on the Japanese Government Railways. All-steel wagons are used for special service. The standard open (gondola) wagons are constructed with steel underframe and side frame, with hinged wood sides.

The standard box wagons are constructed with steel underframe and body framing, and steel outside sheating; wood flooring and inside lining.

Coal wagons are of all-steel construction.

Korea. — On the Korean (Chosen) Government Railways the body and underframe of all-steel mineral hopper wagons are built as one structure and have heavy fish-belly type centre sills. The 30-ton covered wagons are constructed with the body and underframe as one unit, with heavy centre sills; the body framing, outside panels and roof are all of steel, and the floor and inner lining are of wood.

Manchuria. — All-metal wagons on the South Manchuria Railway are constructed with the body and underframe as one unit.

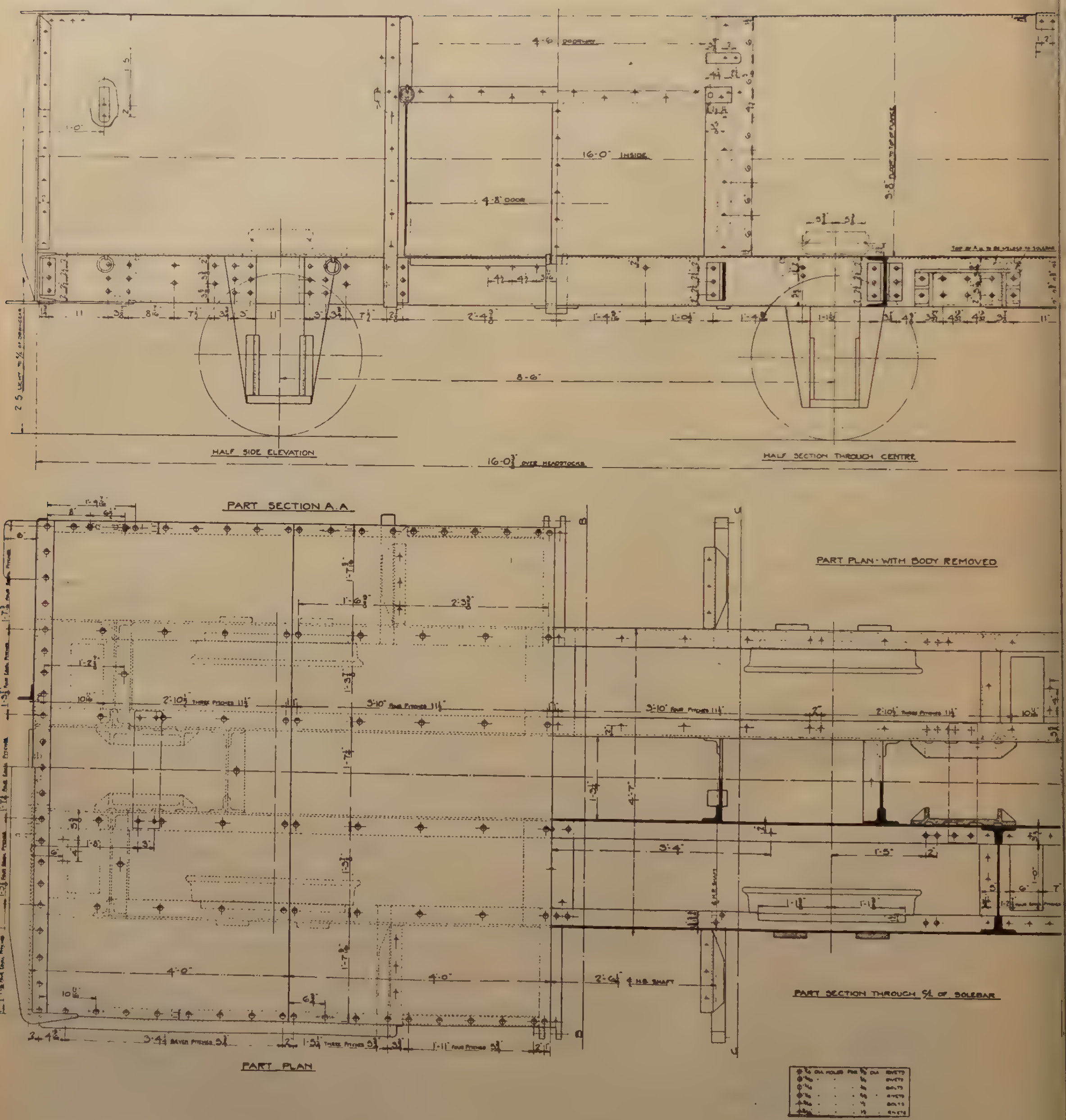
IV. — Materials used in the construction of wagons. Means employed to resist corrosion.

The principal members used in the construction of all-metal wagons are generally made of steel, although iron is used to some extent, the underframe and body frame members being either rolled steel sections or pressings, and the sides, roofs and in many cases the floor of plates or sheets of open hearth steel.

Copper bearing steel, with a copper content varying from 0.20 % to 0.30 % is now used by the majority of the railways as a means of preventing or reducing corrosion. Sandblasting, followed by a coat of priming paint, has also been adopted by some companies with a view to preventing corrosion. Anti-corrosive paints such as red lead, or a paint with an oxide base are also used to a great extent. The adoption of metal spraying with a view to the prevention of corrosion has, up to the present, been very limited. The only Companies covered by the questionnaire, who have stated that they use this method, are the Delaware and Hudson Company and the Wabash Railway. The New South Wales Government Railways report having used metal spraying experimentally.

The practices of the various railways in regard to the above subjects are given below :

Argentine. — On the Buenos Ayres and Pacific Railway, the principal members are constructed of steel 28/32 tons per sq. inch tensile. No special methods are used for resisting corrosion. The Buenos Ayres Western Railway use mild steel for metal members, and no special precautions are taken to prevent corrosion. On the Central Argentine Railway, rolled steel sections are used for the principal members, and lead paint is used for resisting corrosion. The Cordoba Central Railway use mild steel rolled sections for the main metal members.


HALF SIDE ELEVATION
HALF SECTION THROUGH CENTRE
16'-0¾" OVER HEADSTOCKS
4'-6" DOORWAY
16'-0" INSIDE
4'-8" DOOR
8'-6"
PART SECTION A.A
PART PLAN · WITH BODY REMOVED
PART SECTION THROUGH ℄ OF SOLEBAR
PART PLAN

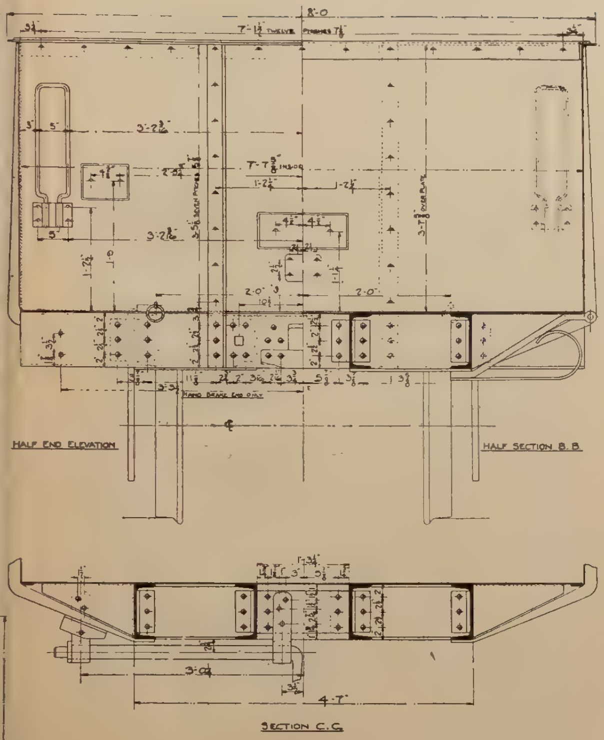


Fig. 17. — Open merchandise wagon, New Zealand Government Railways.

Frame longitudes and headstocks are of mild steel channel 12-in. × 3 1/2-in. × 25.25 lb., and solebars of mild steel channel 8-in. × 3-in. × 15.96 lb. Angle knees are of mild steel channel pressings, and corner gussets of 1/4 inch thick mild steel. Bolsters are composed of 1/4-inch mild steel web plates. A few all-metal covered wagons have the flooring of « Armco » iron.

United States of America. — The Baltimore and Ohio Railroad use copper bearing steel for the principal metal members containing :

Phosphorus, not over . . .	0.05 %
Sulphur, not over.	0.05 %
Copper, not less than . . .	0.20 %

the tensile strength being 50 000/65 000 lb. per sq. inch. The method adopted for the prevention of corrosion is to apply a coat of red lead to all sheets purchased for new work; red lead is also applied where metal is joined to metal, and either riveted or bolted. An anti-corrosive paint — « freight car brown » — is the standard covering for metal wagons. The Delaware and Hudson Company also use copper-bearing steel for metal members. As an anti-corrosive, a priming coat of red lead is applied to metal parts. Metal spraying has also been adopted. On the New York Central Lines steel is used for the principal metal members. A few mineral and open merchandise cars have been equipped with copper-bearing steel sides for experimental purposes only. The sheets used have the same physical and chemical properties as ordinary soft steel plates, except that they are required to contain a copper content of not less than 0.20 %. On covered wagons all surfaces are thoroughly cleaned, and outside surfaces of sides and ends, and the outside of all-steel roofs (except where galvanised) are sandblasted, after which one coat of priming plaint is applied, followed by two coats of finishing

paint on outside and one coat on inside. Underframes, after being cleaned, are given one coat of priming and one coat of finishing paint. On open and mineral wagons the same procedure as above is followed, except that only one coat of finishing paint is used. The insides are not painted. Both priming and finishing coats are applied by the spray method.

The Norfolk and Western Railway use rolled sections of channels, angles and « Zed » bars for the main metal members. Copper bearing steel is used almost entirely. All wagons are painted by the spray method, and the best paint known is used to prevent corrosion. On the Pennsylvania Railroad the principal metal members are of open hearth steel with a copper content of 0.20 %. The Reading Company use structural steel for the main metal members. Copper bearing steel is used for roof sheets to American Railway Association Specification for « Sheet Steel and Thin plates » with a copper bearing content of not less than 0.20 %. A good commercial red lead is used as a corrosion-resisting paint.

The Wabash Railway use open hearth steel for metal members, but copper-bearing steel has been used experimentally. As an anti-corrosive paint, black asphaltum cement is used for underframes. Metal spraying has also been used for covering the metal, with a view to the prevention of corrosion.

Great Britain. — On the Great Western Railway the principal materials used in the construction of all-metal wagons are grade « B » iron for open and mineral wagons, and steel for covered wagons. In 1928, twenty-five 12-ton open goods wagons were constructed with iron substitute, and twenty-five similar wagons were built of copper bearing steel. In 1930, fifty 20-ton coal wagons were also built of copper-bearing steel, with a view to the prevention of corrosion. Oxide paint is also used as an anti-corrosive in the following composition by weight :

Metallic oxide	74 %
Boiled linseed oil	11 %
Turps substitute	9 %
Driers	6 %

Metal spraying has not been tried.

The London Midland and Scottish Railway use mild steel for the main metal members, but copper bearing steel has been used to a limited extent, chiefly as an experiment. Corrosion resisting paint is used for covering metal members, the composition by weight being :

Pymrut (red oxide of iron) . .	65 %
Boiled linseed oil	30 %
Liquid driers	5 %

On the London and North Eastern Railway, the material used in the construction of all-metal wagons is mild steel to British Standard Specification No. 18A, Report No. 24, dated 1929.

A first coat of anti-corrosive paint is used on all-metal wagons and for the underframes and metal framed bodies, the composition by weight being :

Red oxide, dry	60 %
Boiled linseed oil.	26 %
Liquid driers	8 %
Turps substitute	6 %

Africa. — On the Gold Coast Government Railways, the principal metal members are formed of mild steel pressings and plates, the roof sheets of covered wagons being galvanised after bending. Metallic paint (Taylor's Silvereen brand) is used as an anti-corrosive. The Kenya and Uganda Railways also use mild steel for the main members, and an anti-corrosive paint, « Red Danboline », is sprayed on the metal. On the Nigerian Government Railways the principal metal members are formed of rolled steel sections, and the body plates are of mild steel, or, in the case of some types of covered wagons, galvanised plates. « Corrostite » steel has been used experimentally for curb rails on wooden bo-

died stock, but no results are available at present. « Torbay » anti-corrosive paint is also used. On the Sudan Government Railways, where steel is used for the construction of metal members, no special precautions are taken with a view to preventing corrosion.

Australasia. — The New South Wales Governement Railways use rolled steel sections and plates. On a few ballast hopper wagons Keystone copper bearing plates have been used for the bodies, but the experience is not yet sufficient to determine the increase in life. Corrosion-resisting paints and metal spraying have been used experimentally. The New Zealand Government Railways use rolled steel angles and channels and mild steel plates for the main metal members. In order to minimise corrosion, the underframes are painted with coal tar, and the bodies with « Red Oxide » paint, the composition of which is :

Red oxide (Nelson N. Z. product) . .	5 gallons.
Terebene	3 pints.
Boiled oil	1 gallon.
Turpentine	3 pints.

Canada. — On the Canadian National Railways the main metal members are of rolled steel sections and plates. In some cases, copper bearing steel is used with a view to preventing or reducing corrosion. Oxide, or red lead paint is also used. The Canadian Pacific Railway use standard rolled steel sections and open hearth steel plates for the principal members. As a means of preventing corrosion, copper-bearing steel is used, the chemical composition being :

Carbon, not over . . .	0.25 %
Manganese, not over .	0.60 %
Phosphorus, not over .	0.05 %
Sulphur, not over . .	0.06 %
Copper, from 0.20 % to	0.30 %

Anti-corrosive paints are not used, the surfaces of the sheets being sandblasted and primed.

Ceylon. — Tests are now being carried out by the Ceylon Government Railways with bogie coal wagons, which are constructed entirely of wrought (puddled) and wrought (ingot) iron, against steel constructed wagons. This railway has no experience of copper-bearing steel or metal spraying. Lead base paints are used exclusively for protecting steel work on wagons against corrosion.

India. — The Bengal Nagpur Railway use rolled steel channels, angles and bulb angles, « U » sections and steel plates. Bituminous paint and coal tar applied as an anti-corrosive covering on all-metal wagons. The Eastern Bengal Railway use rolled steel channels and angles, and mild steel plates for the principal metal members. These are painted with anti-corrosive « Bitumastic » black paint. On the East Indian Railway mild steel channels are used for the underframe and mild steel angles and plates for the body, the whole being sprayed with a good quality oil paint. The Great Indian Peninsula Railway also use mild steel for the principal metal members, and ordinary paints ground in oil are used as a protection against corrosion.

Federated Malay States. — The Federated Malay States Railways use steel members for the construction of all-metal wagons. Copper bearing steel has been used experimentally for the underframes of cattle wagons. No special precautions are taken to prevent corrosion.

Japan.—On the Japanese Government Railways the principal metal members are chiefly of standard rolled sections, steel pressings and steel plates. Copper-bearing steel sheet is now used for inside waterproof lining, and ceiling ice tanks on refrigerator cars. If the corrosion tests, which are being carried out at the Research Institute, prove satisfactory, a more extensive use of copper-bearing steel will be considered. A copper content of not less than 0.20 % is specified. No special anti-corrosive paints are used.

« Sherardized » bolts and nuts for positions exposed to the weather are now under test. The Korean (Chosen) Government Railways construct all-metal wagons with rolled steel sections and steel plates. No special means for preventing corrosion have been adopted.

South Manchuria Railway. — The principal metal members are of rolled steel, pressed steel and cast steel. With a view to preventing or reducing corrosion « Armco » iron sheets and copper steel sheets are used; the chemical compositions of these are :

« Armco » iron sheets.

Carbon	0.054 %
Silicon	0.01 %
Manganese	0.04 %
Phosphorus	0.011 %
Sulphur	0.035 %

Copper steel sheets.

Carbon	0.15 %
Silicon	0.02 %
Manganese	0.26 %
Phosphorus	0.012 %
Sulphur	0.029 %
Copper	0.178 %

Anti-corrosive paints are used as follows :

One coat of red lead :

Red lead	67 %
White lead	11 %
Boiled linseed oil	15 %
Turpentine	7 %

Two coats of black paint :

Barium sulphate	41.5 %
Boiled linseed oil	48 %
Carbon	2.1 %
Turpentine	8.4 %

V. — Methods of assembly. Riveting and welding.

The general method of assembling metal wagons adopted by all the Railways covered by this report is by riveting. On many railways the various members are first assembled in jigs and riveted, and then the sections are riveted together to form the complete wagon.

Welding, as a means of assembly, is used by some Companies experimentally, and by others it has been adopted to a limited extent for certain joints. Among the reasons advanced against a completely welded structure are the difficulty of preventing the plates from buckling, and the increase in first cost. Many Companies are agreed that welding can be substituted for riveting for all joints, and that the saving in weight of a welded structure would be about 10 % to 15 %.

Both electric arc and autogenous welding are used.

The following summary shows the methods of assembly employed by the various railways :

Argentine. — The Buenos Ayres and Pacific Railway use a riveted and bolted assembly. The Buenos Ayres Western Railway receive the framing riveted in sections from the builders. Oxy-acetylene is used only for joints of tanks on tank wagons. Riveting is also the method of assembly adopted by the Central Argentine Railway, but the substitution of welding for riveting will be considered when new wagons are ordered. The Cordoba Central Railway have not considered the adoption of welding.

United States of America. — The Baltimore and Ohio Railroad use riveting, but state that welding can be substituted for riveting for all joints, but the cost at present is greater. The saving in weight would be about 10 %. The Delaware and Hudson Company consider that welding can be substituted for riveting to a large extent, and the saving in weight would be about 12 % on a completely welded wagon. The New York Central Railroad believe that as progress is made, welding may be largely substituted for riveting. Based on information available, as a result of experiments made by one of the leading car builders, in the construction of 70-ton capacity mineral

cars by the welding process, it is believed that, as progress is made in the development of welded cars for general service, a weight saving of 10 % to 15 % can be obtained. As an experiment the Norfolk and Western Railway have used welding in the construction of one tender tank, but found it more expensive than riveting, and also the source of a great deal of trouble owing to buckling of the sheets. On the Pennsylvania Railroad riveting is the method of assembly mostly employed. When welding is used, it is by autogenous methods. They also consider that welding can be used for all joints, but have no record of saving in weight that would accrue. The Reading Company state that welding can be substituted for riveting, but there would be no saving of weight. The Wabash Railway also consider that welding can be substituted for riveting, but not having any experience in welding, no data can be given re saving in weight.

Great Britain. — The Great Western Railway jig, drill and rivet together the components of all-metal wagons. For experimental purposes, one open goods wagon has been electrically welded, but no details are available. On the London Midland and Scottish Railway members are assembled in a jig and riveted to each other, rolled angle knees and bent plate knees being used. Experiments in welding are being carried out at the present time.

London and North Eastern Railway. — The method of assembly used by this Company is to make all joints or connections by means of angle or plate knees, gusset plates and riveting. Welded joints are not used, but an experimental private owner's wagon, which has been completely assembled by welding, is now running on this Railway and is being carefully watched.

Africa. — Riveting is used for the entire assembly of all-metal wagons.

Australasia. — The New South Wales Government Railways assemble the metal framing in jigs. and fix by riveting. When welding is used for certain joints, it is by the electric bare wire electrode system. Owing to insufficient experience, no expression of opinion can be given regarding the substitution of welding for riveting. On the New Zealand Government Railways special jigs are made, upon which the frames are assembled and riveted. It is considered that welding can be substituted for riveting in the case of all joints, except the attachment of heavy castings, such as draft lugs, but there would be no appreciable reduction in weight.

Canada. — The Canadian National Railways use riveting for all joints, but on the Canadian Pacific Railway electric welding is used for certain joints, and it is considered that, in general, welding can be used for all joints.

Ceylon. — The Ceylon Government Railways have had no experience of welded joints.

India. — On the Bengal Nagpur Railway the assembly of metal framing is carried out by riveting. Welding, by electric arc, is only used for repairing cracked members. The Eastern Bengal Railway use riveting only, while the East Indian Railway use riveting for all joints, except the barrels of tank wagons, these being lap welded by an electric process. The Great Indian Peninsula Railway also use riveting, and have not tried welding.

Federated Malay States. — All-metal wagons for the Federated Malay States are constructed in England, and riveted joints are used.

Japan. — The assembly of all-metal frames is carried out chiefly by riveting on the Japanese Government Railways. Welding is used for some joints, electric and autogenous methods being used, according to requirements. The Korean (Chosen) Government Railways use ri-

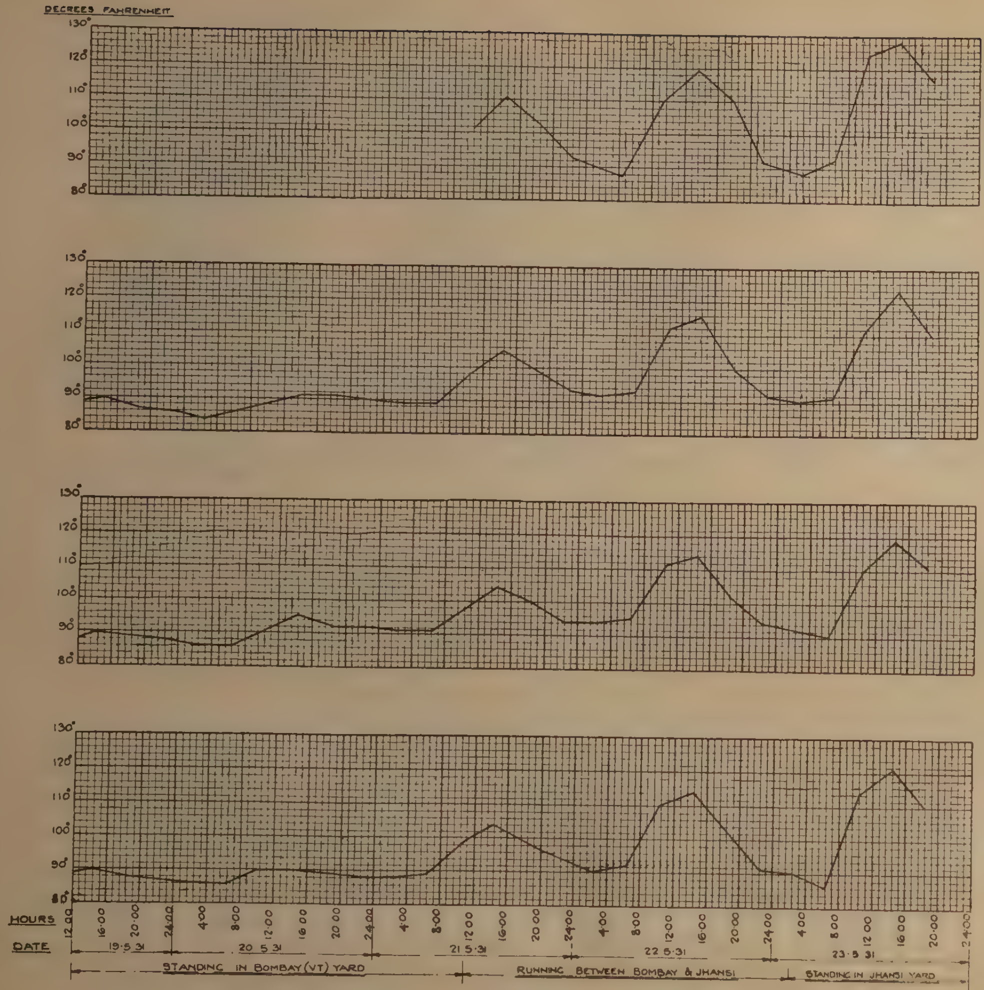


Diagram No. 310.

4-wheeled wagon of all-steel construction with protected gauze wire ventilators. The total area of the sides and roof is 492 sq. ft., of which 26 sq. ft. or 5.03 % is occupied by the ventilating panels.

Diagram No. 260.

Bogie wagon with steel body and wood ventilating louvres The total area of the sides and roof is 940 sq. ft., of which 184 sq. ft., or 19.5 % is occupied by the ventilating panels.

Diagram No. 261.

4-wheeled parcel van with a body of wood framing and steel panel sides, wood roof and wood ventilating louvres. The total area of the sides and roof is 460 sq. ft., of which 163 sq. ft. or 35.5 % is occupied by ventilating panels.

Diagram No. 260 A.

Bogie parcel van with a body of wood framing and steel panel sides, wood roof and steel plate ventilating louvres. The total area of the sides and roof is 1 609 sq. ft., of which 224 sq. ft. or 13.9 % is occupied by ventilating panels.

Fig. 18. — Temperature-time curves for different types of luggage vans, Great Indian Peninsula Railway.

veting for assembling all-metal frames, but according to present experience, consider that welding can be substituted for some joints only.

South Manchuria Railway. — The assembly of metal frames is carried out by riveting, but electric welding is used for some joints, and it is considered advantageous to use welding as far as possible.

VI. — Heat insulation.

The question of heat insulation creates a difficult problem in some countries owing to climatic conditions. Whilst some railways report that they experience no difficulty in this matter, others find that for traffic in which heat insulation is an important factor, all-metal bodies are not desirable.

Figure 18 gives diagrams of results obtained on the Great Indian Peninsula Railway with metal and composite bodies and shows a slight advantage in favour of the composite construction.

Insulating materials, such as hair felt or cellular asbestos compositions, are used between the outside and inside panels by some railways, but the most widely used method of insulating is the fitting of an inside lining of wood, with an air space between the lining and the outside panels.

In the Argentine the provision of insulation is not considered necessary for ordinary covered all-metall wagons; perishable goods are carried in special ventilated and insulated vans.

In the United States of America, the general practice is to fit an inner lining of wood casing boards, leaving an air space between the lining and the outside metal panels. The Reading Company use hair felt insulation.

In Canada the Canadian National Railways do not insulate covered wagons, but the Canadian Pacific Railway have adopted the practice of fitting a wood side and roof lining.

In Great Britain the Great Western Railway fit end ventilators, and the London Midland and Scottish Railway fit an inner lining of wood with an air space between it and the outside panels.

In Africa no provision has been made in regard to heat insulation beyond the fitting of ventilators.

In Ceylon and India large louvre type ventilators are fitted in the sides of covered wagons.

On the Federated Malay States Railways metal bodies are not usually used for vehicles in which heat insulation is an important factor, but where metal has been used, the body is double lined, leaving free air spaces between the outer and inner panels. Insulating materials such as « Celotex » have occasionally been used.

In Japan insulation is provided by the use of a wood roof and lining boards.

The South Manchuria Railway overcome the problem of heat insulation by fitting interior panels of wood, and lining the roof with fibre board.

To prevent condensation the inside of the outer panels is sometimes covered with a layer of heavy sawdust or granulated cork applied on a paint paste. This method is used by the Canadian Pacific Railway.

The practice of leaving a free air space between the outer and inner panels, adopted by some railways, also helps to overcome the problem of condensation.

VII. — General remarks.

The replies show that the general tendency is towards metal construction for wagons in order to provide greater strength to resist the rough treatment to which goods wagons are subjected.

In order to overcome the corrosion, which is particularly destructive in the case of mineral wagons, iron is used in some cases in preference to steel, but copper bearing steel is more generally employed.

Timber is still being used to a large extent for the bodies of wagons, and

there does not appear to be any prospect of its use being entirely eliminated by metal.

Whilst riveting is the general method used for connecting together the details of wagons, welding is being experimentally tried on a wide scale. The results are not yet conclusive, and although a reduction of weight of from 10 % to 15 % is mentioned in some instances, no evidence is yet available as to the eventual savings in regular practice. The cost of welding appears to be appreciably higher, as would be expected from the amount of labour required. Electric arc and autogenous welding are both used, no definite preference for one or the other system being observable from the replies.

As regards heat insulation, no general practice is followed, wood linings with air spaces being the most common practice. Condensation inside steel stock causes trouble in some countries, and the measures taken to overcome it are to line out the vehicles with wood, or to coat the interior with paint paste and apply granulated cork or sawdust which is then painted over.

It is satisfactory to note that there is an increasing tendency towards standardisation of design, which has a marked effect on the cost of construction, and also on the cost of maintenance.

APPENDIX I. — QUESTIONNAIRE.

The questionnaire reproduced on pages 1514 and 1515 here-after was sent to the following eighty-six Railways, the thirty-three replying being indicated by an asterisk :

Railway Company.

Argentine (Republic).

State Railways.
Buenos Ayres Great Southern Railway.
*Buenos Ayres and Pacific Railway.
*Buenos Ayres Western Railway.
*Central Argentine Railway.
*Cordoba Central Railway.
Entre Rios Railways.
Chemins de fer de Rosaria à Puerto Belgrano.
Chemins de fer de la province de Santa-Fé.

Brazil.

Compagnie des Chemins de fer de l'Est brésilien.
Great Western of Brazil Railway.
Leopoldina Railway.
Chemins de fer de Rio Grande do Sul.
Estrada de Ferro Sorocabana.

Chili.

Antofagasta (Chili) and Bolivia Railway.
Nitrate Railways.
Taltal Railways.

China.

Chemin de fer du Lunghai.
Chemin de fer de Pékin-Hankow.
Compagnie générale de chemins de fer et de tramways en Chine.
*South Manchuria Railway.

Colombia.

*Société nationale de chemins de fer en Colombie.
The Colombia Railways & Navigation Company Ltd.

United States of America.

*Baltimore and Ohio Railroad Company.
Bessemer and Lake Erie Railroad.
Central of Georgia Railway.
*Delaware and Hudson Company.
Erie Railroad.
Illinois Central Railroad.
Kansas City Southern Railway.

Lehigh and New England Railroad.
Long Island Railroad.
*New York Central Railroad Company.
*Norfolk and Western Railway Company.
*Pennsylvania Railroad Company.
Pittsburgh, Shawmut and Northern Railroad.
*Reading Company.
Richmond, Fredericksburg and Potomac Railroad.
*Wabash Railway Company.

Great Britain and Northern Ireland.

*Great Western Railway.
*London Midland & Scottish Railway.
*London & North Eastern Railway.
Southern Railway.
Great Northern Railway.
Isle of Man Railway.
Kent, Somerset, Shropshire and Welsh Light Railways Group.
Metropolitan Railway.
*Underground Electric Railways Co. of London.
County Donegal Railways Joint Committee.
London Midland & Scottish Railway Co. (Northern Counties Committee).
Midland and Great Northern Railways (Joint Committee).

Africa.

*Gold Coast Government Railways and Harbours.
*Kenya and Uganda Railways and Harbours.
Mashonaland Railway.
*Nigerian Government Railway.
South African Railways and Harbours.
*Sudan Government Railways and Steamers.

Australasia.

*New South Wales Government Railways.
*New Zealand Government Railways.
South Australia Government Railways.

Canada.

*Canadian National Railways.
*Canadian Pacific Railway.
Quebec Central Railway.

Ceylon.

*Ceylon Government Railway.

India.

*Bengal Nagpur Railway.
Bengal and North Western Railway.
Bombay, Baroda and Central India Railway.
Burma Railways.
*Eastern Bengal Railway (State Railway of India).
*East Indian Railway (State Railway of India).
*Great Indian Peninsula Railway (State Railway of India).
*Madras and Southern Mahratta Railway.
North Western Railway (State Railway of India).
Rohilkund and Kumaon Railway.
South Indian Raiway.

Irish Free State.

Great Southern Railways.

Malaya.

*Federated Malay States Railways.

Mesopotamia.

Iraq State Railways.

Japan.

*Japanese Government Railways.
*Korean (Chosen) Government Railways.

Mexico.

Ferrocarriles Nacionales de Mexico.

Salvador.

Salvador Railway.

Uruguay.

Central Uruguay Railway of Montevideo.
North Western of Uruguay Railway.

* * *

American Railway Association.
Railway Clearing House (Gt. Bn.).

List of questions.

Note. — *It should be understood that an all-metal carriage is one in which the underframe, the body framing and exterior panelling are entirely of metal.*

CARRIAGES.

I. — General considerations.

The advantages of carriages entirely constructed in metal.

a) Is it your policy to develop the construction of all new carriages in metal ?

b) If not, are you intending to develop the construction of metal carriages to a limited extent ?

c) What are the reasons which justify your policy ?

II. — Progress and types of metal construction.

Types of carriages which are running, under construction, or in process of being designed.

a) What will be the percentage of all-metal carriages on your system at 1st January 1932 ?

b) Will you have any others under construction ?

c) Have you constructed or are you designing any types of all-metal carriages other than those mentioned in the reports given at the Session held in Madrid in 1930 ?

d) Types of carriages. Subsections *b* and *c*.
 (1) With doors at ends only.
 (2) With compartment doors.

e) Services for which required :
 (1) Main line.
 (2) Suburban.
 (3) Metropolitan.
 (4) Carriages on light railways (tramways).

f) What is the general principle underlying their construction :
 (1) Body independent of and entirely carried by underframe.
 (2) Body and underframe treated as one structure.

Please submit drawings shewing the gener[al] construction of new carriages. Subsections [*b*)] and *c*).

III. — Methods and materials used in construction.

a) What materials do you use for the pri[n]cipal metal members forming :
 (1) The body.
 (2) The underframe.
 (3) The bogies.

of the carriages mentioned in question [II,] subsections *b*) and *c*).

b) When steel is used what parts are ma[de] in :
 (1) Standard rolled sections.
 (2) Special rolled sections.
 (3) Pressed steel.
 (4) Cast steel.

c) Where light metals or light alloys a[re] used give full particulars of the deta[ils] for which they are used.

d) Give chemical composition and physic[al] characteristics of light alloys.

e) Where light alloys and light metals a[re] used what precautions are taken for t[he] prevention of corrosion between t[he] joints of such members and anoth[er] metal ?

f) What materials are used for the followi[ng] parts of the carriages mentioned [in] Question II :
 (1) Exterior panels.
 (2) Interior panels.
 (3) Partitions.
 (4) Floor.
 (5) Roof.

Please supply drawings shewing sectio[ns] through these parts.

g) How do you overcome the problem of he[at] insulation on the panels of all-me[tal] carriages ?

h) (1) What methods of assembly do you u[se] for the metal framing ?
 (2) If welding is used for certain joi[nts] what system of welding is employe[d] ? And what special precautions a[re] taken to prevent local deformati[on] or buckling ?

(3) What special methods are adopted for the assembly of details in light steel construction and in light metal or light alloy construction. If riveted state in each case of what material rivets are made.

Do you consider that welding can advantageously be substituted for riveting in the assembly of all-metal vehicles, for all joints or for some joints only.

Please give your reasons.

What reduction in weight has been effected by welding in place of riveting steel parts ?

Do you use light metals or light alloys for the fittings of compartments, corridors, vestibules and lavatories ?

What reduction in weight has been effected by the use of light metals or light alloys ?

If no such comparison can be made, an estimate of the reduction in total weight can be furnished by making comparison of the weight of the various parts made in light metal or light alloy.

How far has the cost been increased by the use of light metals or light alloys ?

WAGONS.

Note. — *This questionnaire has reference ly to the use of metal construction for open d covered wagons used for the conveyance general merchandise and wagons used for al, coke and other mineral traffic.*

I. — General considerations.

The advantages of wagons entirely con-ucted in metal.

Is it your policy to develop as far as possible the construction of all new open, covered and mineral wagons entirely in metal ?

If not, are you intending to develop the construction of metal wagons to a limited extent?

What are the reasons which justify your policy ?

II. — Types of metal construction.

a) What proportion of the stock of the following types of wagons on your system are constructed :

(1) Entirely of metal.

(2) With underframes and body framing only of metal,

Under the following heads :

Open merchandise.
Covered merchandise.
Mineral merchandise.

b) What is the general principle underlying the construction of your all-metal wagons ?

Drawings to be submitted of each type :

(1) Open.
(2) Covered.
(3) Mineral.

III. — Methods and materials used in construction.

a) What materials do you use for the principal metal members of the wagons mentioned in Question (II) ?

b) Do you use copper bearing or other alloy steels with a view to preventing or reducing corrosion ? If so, please give the chemical composition and physical characteristics of the materials.

c) Do you use any corrosion resisting paints? If so, please give composition.

d) Have you adopted metal spraying or any other method of covering the metal, with a view to the prevention of corrosion ?

e) How do you overcome the problem of heat insulation and condensation in all-metal covered wagons ?

f) (1) What methods of assembly do you use for the metal framing ?

(2) If welding is used for certain joints, what is the system employed ?

g) Do you consider that welding can be substituted for riveting in the assembly of all-metal vehicles, for all joints or for some joints only ?

h) What reduction in weight is effected by welding in place of riveting ?

APPENDIX II.

Summary of railway practices (Replies to questionnaire).

CARRIAGES.

Argentine.

Central Argentine Railway.

I. *General considerations.*

a) Yes.

c) Less liable to damage in cases of fire and accident — therefore travelling is made safer.

II. *Progress and types.*

Types : First and second class passengers cars, sleeping cars, dining cars, saloon cars, brake vans, luggage vans, etc.

a) 22 %.

c) Yes, first and second class electrified suburban cars, dining cars, sleeping cars, restaurant cars, brake vans, etc.

d)1) Main line stock.

2) None, but suburban stock has double side doors at centre.

e)1) Main line stock.

2) Electrified suburban stock (first and second class motor coaches and trailers only).

f)2) Body and underframe treated as one structure, so as to eliminate trussing of underframe.

III. *Methods and materials used.*

a)1) Pressed steel pillars and carlines etc., 1/8″ thick.

2) Rolled steel sections.

3) Built up of steel plates, rolled steel sections and steel castings.

b)1) Underframes built up of standard rolled sections.

3) Body pillars and carlines are special pressed sections.

4) Bogie centre plate castings, axleboxes etc., etc.

c) A light metal alloy (Alpax) is used for window frames, seat pedestals, parcel rack supports, etc.

d) Alpax metal (aluminium-silicon alloy of a patented composition).

e) By painting with anti-corrosive paint.

f)1) Steel plate 3/32″.

2) Plywood.

3) Plywood, with timber framing.

4) « Decolite » composition, over galvanized iron dovetail sheeting.

5) Steel plates outside, plywood inside.

g) Actually the outside metal sheeting of the body is not insulated. The insulation consisting of asbestos aircell insulation, is fixed against the inner plywood panels. For future stock the insulation of the steel sheeting will be considered.

h)1) Riveting.

3) Riveting by means of steel rivets, where steel construction is concerned.

Riveting by means of aluminium rivets, where « Alpax » metal is concerned.

j) Possibly; this matter will be given consideration when new coaches are designed.

l) See question III, section *c*).

m) In the case of our main line first class cars, where « Alpax » metal has been made the greatest use of, the saving in tare weight is about 0.5 ton.

n) Detail costs are not yet in our possession.

Note : The *Buenos Ayres and Pacific* Railway and the *Cordoba Central* Railway have no all-metal carriages, and the *Buenos Ayres Western* Railway replys that « No new types of carriages are contemplated for the present ».

United States of America.

Baltimore & Ohio Railroad.

I. *General considerations.*

a) Yes, all cars built since 1911.

b) All new equipment to be of metal.

c) All-steel equipment has longer life, and less maintenance cost.

II. *Progress and types.*

a) 51 %.

b) No.

c) 172 cars.

d)1) Coaches, colonial dining cars, parlour cafe cars.

2) None. Baggage cars are fitted with side doors.

e)1) Type of cars mentioned in paragraph *d*) used for main line.

2) No service.

3) Coaches and combine cars.

4) Gas-electric motor car with trailer.

f)1) Body is carried entirely by the underframe and is not independent of it, floor supports are secured to transverse and longitudinal members of underframe, also the vertical members of body and girder sheet are riveted to side sills.

2) Yes.

III. *Methods and materials used.*

a)1) Sheet steel, pressed and rolled sections of steel having copper bearing content of not less than 0.20 %.
2) Rolled sections for side and centre sills, bolsters and needle beams. Diaphragms of pressed steel, web and cover plates of sheet steel. Platforms of cast steel riveted to side and centre sill.
3) Cast steel.

b)1) Side plate of body, belt rail, top and bottom angles of centre sill, vestibule and diaphragm post.
2) None.
3) Carlines in roof, vertical members in body, diaphragms or pans in underframe.
4) End sill or buffer casting, reinforcement for body bolster. Truck frame, cross and centre bolsters, arch bars and spring planks.

c) Two trailer cars have aluminium wainscoting, pier and frieze panels, headlining and ceiling.

d) Commercial article known as No. 12 aluminium and contains 8 % to 12 % copper.

e) Layer of felt placed between all joints of aluminium with steel.

f)1) Roller levelled sheet steel with copper bearing content.
2) Roller levelled sheet steel with copper bearing content.
3) Roller levelled sheet steel with copper bearing content.
4) Coaches, passenger compartment of combine cars and diners have corrugated iron which is covered with flexolith. Baggage and baggage end of combine cars—wood.
5) Steel 0.078″ thick.

g) Three-ply Salamander applied on inside of outside sheets and 2-ply applied to back of interior sheets with nails or cleats spot welded to panels. After Salamander is applied thin washers are placed over points or nails before they are bent over. (1-ply of Salamander is approximately 1/4″ thick).

h)1) Riveting.
2) Electric arc welding. No welding performed on thin sections or at joints. When replacing car roofs, one end is welded and the other riveted, this eliminates the necessity of removing head lining.
3) All-steel cars, steel rivets are used. Interior finish such as panels, ceiling sheets, etc., are applied with machine screws to framing.

j) We have not built any welded passenger cars, only one welded hopper car, 95-ton capacity, having been constructed which had all the joints welded, which we believe can be advantageously done, as we have had the car in service for quite a long time with no evidence of weakness developing. The welded car is more costly to build than the riveted car.

k) On a welded car we effect saving of about 10 % in weight.

l) 1/16″ steel for partitions and necessary pressings.

m) So far we have never used light metals or light alloys in construction of the passenger cars.

n) See answer to *m*).

Delaware & Hudson Company.

I. *General considerations.*

a) No.
b) No.
c) A car of composite construction if properly designed, is equally as strong as the all-steel cars; is easier to maintain and more comfortable, as it is not subject to the sudden changes in temperature met with in the all-steel car, being warmer in winter and cooler in summer.

II. *Progress and types.*

a) 10 %.
b) No.
c) Five combined mail and baggage cars constructed to meet U.S. Government requirements.
d)1) Cars have end and side doors.
2) None.
e)1) Main line.
f)1) No.
2) Yes.

III. *Methods and materials used.*

a)1) Rolled steel and pressed steel.
2) Cast steel and rolled steel.
3) Cast steel, rolled steel wheels.

b)1) Centre sills, side sills, cross bearers, cross ties, side frames, roofs and ends.
2) None.
3) Body bolsters, cross bearers, side frames, roofs, ends.
4) End sills, centre plates and fillers, truck frame, bolsters and spring planks.

c) None used.

f)1) Blue annealed steel, roller levelled.
2) Baggage compartment, galvanised corrugated steel. Mail compartment, flat steel.
3) Rolled and pressed steel.
4) Rolled and pressed steel, sub floor, wood, top floor.
5) Rolled and pressed steel.

g) Apply one course of 3/4″ three-ply Salamander insulation to the inside of side sheets, end sheets, roof sheets, and two-ply Salamander insulation on top of steel floor.

h)1) Riveting.
2) Welding system not employed.
3) Do not use light alloy construction.

j) Too early to give an opinion as welding of car framing is in the experimental stage.

k) No data.

l) None used.

New York Central Railroad.

I. *General considerations.*

a) Yes, except a few minor details such as arm rests seat coverings, etc.

b) See reply to question *a*).

c) Safety, longer life and reduced repair costs.

II. *Progress and types*

a) 100 % in main line service and practically 100 % in all other services.

b) No. All-metal construction used exclusively.

c) Yes. Double unit dining car, 74′6″ de luxe coach. Multiple unit coach (suburban).

d)1) Doors at ends only except side door in kitchen of dining car.
2) Interior compartment doors open into main passageway which in turn leads to end doors.

e)1) Double unit dining car and de luxe coach for main line service.
2) Multiple unit car.

f)1) Side carrying construction. The ends of the sides are supported by the bolsters which, in turn are carried on the centre plates. We do not use what is known as strictly underframe carrying construction. Depth of side and high moment of inertia precludes the possibility of the underframe supporting other than certain portions of the primary loads.

III. *Methods and materials used.*

a)1) Body and roof framing, rolled and pressed steel shapes. Side and end sheathing, roller levelled, blue annealed steel plates. Roof sheets, copper bearing steel.
2) Combined body bolster and platform and cross bearers, cast steel; pressed and rolled steel shapes and plates.
3) Cast steel one piece frame; wrought steel multiple wear wheels; wrought iron drop equalizers; clasp brake. 6-wheel bogies under diner; 4-wheel bogies under coach and multiple unit car.

Note : Information given under 1), 2) and 3) above does not apply in all respects to M.U. cars, the design of which contemplates the use of aluminium alloys throughout. 4-wheel bogies of built-up steel construction.

b)1) See section (*a*), questions 1), 2) and 3) above.

c) Investigations and designs have not progressed to a point where we are in a position to supply this detail information.

f)1) Roller levelled, blue annealed steel plates.
2) Furniture steel.
3) Furniture steel.
4) Corrugated steel sheets (key type) galvanized, with composition flooring laid over.
5) Copper bearing steel sheets.

g) 3/4″ three-ply insulation on inside of outside panels including roof, and two-ply or 1/2″ insulation on inside of panels. The ceiling is formed of 3/16″ composition board.

h)1) Riveted connections.
2) Welding of parts and entire structure is now being considered but the matter still is in the experimental stage. We use welding at piers between windows where same butt belt rail capping, also at joint of roof sheets. Both arc and autogenous methods are used, depending on conditions and facilities available. Due to small sections welded, no difficulty is encountered due to buckling.
3) Electric spot welding for certain parts of light steel construction.

j) We believe that during the next few years much progress will be made in producing successful welded constructions and that as progress is made welding will gradually be substituted for riveting especially where saving in weight is important.

k) We have no completely welded constructions on which to base reply to this question but from our studies of the matter it is believed that from 10 % to 15 % reduction in weight may be expected.

l) No.

m) No data on which to base reply.

n) No definite information is as yet available on which to base reply to this question.

Norfolk & Western Railroad Company.

I. *General considerations.*

a) Yes.

c) The construction of all-metal carriages was decided upon on account of strength, durability, and decreased cost of maintenance.

II. *Progress and types.*

a) The percentage of steel carriages on 30 June, 1931 was 60 %; wood 40 %.

b) We have no others under construction.

c) We are not constructing or buying any types of all-metal carriages other than those we have.

d)1) Our cars, as a whole, are corridor cars with end doors only.

2) We have a number of partitions in cars separating them into smoking compartments and for other purposes.

e)1) We are using them for all types of service, main line and local, but we do not have any distinctive suburban or metropolitan service on the Norfolk & Western Railway.

f)1) We have no cars in which the body is independent of and carried entirely by the underframe.

2) In all our cars the body and underframe are necessarily treated as one structure, as they are so distinctively tied together

III. *Methods and materials used.*

a)1) Carbon steel.

2) Carbon steel; some rolled sections, some pressed.

3) Truck frames of cast steel; wheels of wrought steel.

b)1) Standard rolled sections entering into the sills and very often the construction of the other parts.

2) We try to fit special rolled sections altogether.

3) A very large proportion of the work that is to be shaped is pressed into desirable shapes.

4) Certain portions of the car around the draft rigging, centre plates and buffers are made of cast steel.

c) We have not been using any special light metals or light alloys.

f)1) Copper-bearing steel (rust resisting).

2) Copper-bearing steel (rust resisting).

3) Copper-bearing steel (rust resisting).

4) Cork tile, with magnesium chloride solution as binder.

5) Copper-bearing steel (rust resisting).

g) In order to do so, we insulate the inside and outside sheets.

h)1) Certain sheets are welded at special places where it has to be made tight.

2) We use electric welding. No appreciable amount of buckling takes place with limited amount of welding.

3) Where conditions permit, parts of light construction are assembled in multiple. Rivets used are of commercial material.

j) Riveting is preferred to welding. Welding is used mainly for closing joints in sheets. New construction as well as repair work, can be performed quicker by riveting than by welding.

k) We have not attempted any amount of welding.

l) We use no light metals or alloys for general fittings.

Pennsylvania Railroad.

I. *General considerations.*

a) Yes.

c) Safety, fire hazard, economy.

II. *Progress and types.*

a) 100 %.

b) Yes.

c) Yes.

d)1) Double-deck and standard electric cars.

e)2) Suburban.

f) 1) Body independent and carried by underframe.

III. *Methods and materials used.*

a)1) Copper bearing steel or aluminium.

2) Copper bearing steel or aluminium.

b)1) Centre and side sills and end posts.

2) None.

3) Posts, braces.

4) End casting, draft casting and anchor castings.

c) Entire construction of car.

d) Aluminium of various grades.

e) None, except paint.

f)1)2)3) and 4) : Copper bearing steel or aluminium.

5) Copper bearing steel or aluminium.

g) Apply hair felt insulation to inside of outside sheets of car.

h)1) Lap joints riveted.

2) Gas or electric.
None.

3) Riveted, with steel or aluminium rivets.

j) Welding can be used for all joints in the general construction of the car in place of rivets, but cannot be used on the inside finish because welding would distort and buckle the thin sheets.

k) None.

l) No. We use the same material as that used for inside finish, either copper bearing steel or aluminium.

m) 40 %.

n) 20 %.

Reading Company.

I. *General considerations.*

a) Yes.

c) Greater strength, life, and less repairs.

II. *Progress and types.*

a) Practically 90 %.

b) No.

c) No.

d)1) All passenger coaches.

e)1) Main line.

2) Suburban.

3) Metropolitan.

f) 1) Yes.

2) No.

III. *Methods and materials used.*

a)1) Sheet steel and structural steel.
2) Sheet steel and structural steel.
3) Cast steel.

b)1) Framing.
2) None.
3) Fillers and corner connections and carlines.
4) End sills and truck frames.

c) 70 multiple-unit electric cars now under construction with aluminium alloy parts, such as floor sheets, roofs, vestibule end sheets, body end, roof, side and end lining parcel racks.

d) Aluminium Company of America specifications.

e) By painting with red lead.

f) With the exception of multiple-unit electric cars mentioned above, the following material is used:

f)1)2)3) and 4) : Steel.
5) Steel.

g) « Johns-Manville » or « Keasby & Mattison » hair felt lining.

h)1) Riveting.
3) Soft steel rivets are used except in aluminium where aluminium rivets are used.

j) Yes. Experience has shown that if properly made, the welded joint is as strong as the riveted joint at present used.

k) None.

l) Aluminium parcel racks in multiple unit electric cars.

m) 6 640 lb.

n) 1 475.00 dollars.

Wabash Railway.

I. *General considerations.*

a) Yes.

c) Reduced maintenance, reduced fire hazard, stronger construction.

II. *Progress and types.*

a) Probably about the same as at present; 38 %.

b) Cannot say at this time.

c) Three.

d)1) Combination baggage and postal cars have doors at ends and sides.

e)1) Main line.

f) 2) Body and underframe treated as one structure.

III. *Methods and materials used.*

a)1) Steel. Rolled shapes, pressings, plates.
2) Steel castings, rolled shapes, pressings and plates.
3) Steel castings, forgings, malleable castings.

b)1) For reinforcing members in underframe and certain superstructure members.
2) None.
3) Window frames and sills, roof carlines, some posts and braces.
4) Combined body bolster and end sills, centre sill separators, cross bearers, truck frames.

c) For inside lining. In baggage compartment, corrugated.

d) Ordinary open hearth steel.

e) Rust resisting paint or cement used at joints.

f)1)2) and 3) : Open hearth steel.
4) Open hearth steel for sub-floors. Top floor wood.
5) Open hearth steel, galvanised.

g) By insulating the inside of the outside and inside sheets with hair felt or other insulation.

h)1) Riveting.
3) Riveted in some cases, and secured by machine screws in other cases. When riveted, soft steel rivets are used.

j) Yes, with the possible exception of some joints. Main reason is, it avoids joints which, regardless of all precautions, will deteriorate due to rust. Also reduces weight.

k) We have had no actual experience.

l) Yes.

m) Cannot say.

n) Having never constructed any cars with other than light metals for parts shown at *l*) we have no record.

Canada.

Canadian National Railways.

I. *General considerations.*

a) Yes.

b) We are building all-steel carriages.

c) Safety and strength.

II. *Progress and types.*

Types: Sleeper, diners, parlor cars, coaches, baggage and mail cars.

a) 36.61 %.

b) Doubtful, depending on business offering.

c) No.

Types: All passenger carrying cars have end doors only.

d)1) Baggage cars, side and end doors.

e)1) All main lines.

f) 1) No.
2) Yes.

III. *Methods and materials used.*

a)1) and 2) Rolled steel for body and underframes.
3) Bogies are cast steel on present equipment, and if any are built in future, the same practice will be followed.

b)1) Underframe and superstructure.
2) Nil.

3) Carlines and posts and diaphragms.
4) All castings, such as buffers, bolster centre fillers and draft lugs.

c) Do not use.
d) Nil.
e) Nil.
f) 1) Copper bearing steel.
2) Furniture stock steel for metal panels.
3) Wood and steel.
4) Wood.
5) Wood and canvas.

g) By using « Salamander » insulating material on the back of steel panels.
h) 1) Riveting.
2) No.
3) No.

j) Nil.
k) Nil.
l) No.

Canadian Pacific Railway.

1. *General considerations.*

a) Yes, for the underframes and outside shell, with wood interior finish.
c) Principally strength requirements on account of heavier trains and increasingly severe service.

II. *Progress and types.*

Types : All new passenger equipment is now of steel construction.
a) 26 %.
b) Yes, in all probability.
c) Details of design change continually.
Types : All cars have end doors only, excepting mail and baggage cars which have side doors in addition.
e) 1) Main line principally.
f) 1) No cars of this type.
2) Fish belly centre sills.

III. *Methods and materials used.*

a) 2) Built up from O.H. steel plates, angles and pressings and underframe end castings. — see drawings.
3) One piece, cast steel.

b) 1) Angles, etc. on sides, ends, roofs and underframes.
3) Corner post pressings, etc., carlines.
4) Body end castings of underframe.

c) Experimental use has been considered in some instances.
f) 1) Patent roller levelled steel sheets.
2) General interior finish of wood.
5) Steel roof frame, with wood and canvas sheathing.

g) By the application of 3-ply « Salamander » insulation secured to the inside of outside sheets by wooden furring bolted to framing.
h) 1) Underframe, sides and roof built separately on jigs.
2) Joint between belt rail and side sheets is electric welded and ground smooth after being riveted. Ordinary care by skilled workmen only precautions necessary to prevent buckling. Material is fairly heavy. The splice places at back of girder joints are also welded.
3) None.
All rivets smaller than 3/8″ dia. are cold pressed and cold riveted. Rivets made of 0.15 % carbon steel.

j) Yes, if a first-class welding job can be secured with quantity production. Consider that special means for automatic electric welding will be required before welding will supplant riveting.
l) No.

Great Britain.

London Midland & Scottish Railway.

I. *General considerations.*

a) We are experimenting, but have not yet sufficient information as to costs etc., to decide what our policy is to be.

II. *Progress and types.*

Types : Corridor first class brakes, vestibule cars, vestibule brakes, corridor third class brakes, and passenger vans.
a) 2.72 %.
b) Yes.
c) Yes.
d) *Types :* Corridor first and third brakes.
1) Yes.
2) No.

e) 1) Main line.
2) No.
3) No.
4) No.

f) Body, sides, ends, roof and underframes built in separate units, assembled and riveted to underframe. Built on underframe and treated as one structure.
1) No.
2) Yes.

III. *Methods and materials used.*

a) 1) Mild steel.
2) Rolled mild steel sections, with cast steel buffer brackets.
3) Rolled mild steel sections, cast steel and cast iron.

b) 1) Body, carlines, and framing.
2) Curb angles, outer cant rail and gutter. Carlines and dovetailed floor sheets.
3) Pillars.
4) Centre pin castings, buffer cylinders and sleeves, buffer brackets.

c) Door drop lights and quarter light mouldings.

d) Silicon 8 to 15 %.
Aluminium 85 to 92 %.
Tensile strength, 12 to 15-tons per square inch.

e) Bedded in red lead or other rust-resisting compound.

f) 1) No. 14 S.W.G. Best black steel sheets, charcoal finish, hydraulically stretched.
2) Wood.
3) Wood.
4) « Decolite » or « Induroleum » laid on dove-tail sheeting.
5) No. 16 S.W.G. mild steel sheets, stretched flat but ordinary finish.

g) No insulation material used; the body is designed with a continuous air space from 2″ to 3″ between the interior and exterior panelling which allows a current of air to flow continually through the shells.

h) 1) Jigs used for body side, roof and ends; the body side constructed on two main longitudinal members, viz.: cant rail and curb rail. These members are fixed and gauged in the body side jigs. The body side pillars and panels are bolted to their respective holes to the above members previously to riveting. Similar method, adopted for roof and ends.
2) Welding is used for butt joints exposed to the weather. Such joints are welded by metalled arc system. Special precautions to prevent local deformation and buckling are: 1) sufficient clearance between plates, and 2) correct electrodes and current value used.
3) In riveting construction we use 1/4″ to 5/16″ diameter soft wrought iron rivets, fixed cold for body sides, and end panels and roof. Usually when larger rivets are used, these are of mild steel and heated.

j) We have not had any experience, and, therefore, cannot say.

l) No.

m) Does not arise.

n) No experience.

London & North Eastern Railway.

I. *General considerations.*

a) No.

b) Yes.

c) All metal carriages are heavier and more costly than those with wooden bodies. The Company's shops are laid out for building and repairing wooden bodies. Further development would depend on costs being reduced.

II. *Progress and types.*

Types : Open thirds, brake vans, kitchen cars, steam rail coaches.

a) 1.02 %.

b) No.

c) No.

d) 1) None.
2) None.

e) 1) Does not apply, in view of reply to b and c.

III. *Methods and materials used.*

a) 1) As no coaches are being built or designed, this question, with its sub-sections cannot be answered.

Metropolitan District and London Electric Railways.

I. *General considerations.*

a) Yes, except for certain interior fittings and finish.

c) Strength and freedom from fire risks.

II. *Progress and types.*

Types : Tube and sub-surface railway passenger vehicles (electric).

a) 89.3 %.

b) Yes.

d) 1) Saloon type cars with side sliding doors and end doors.
2) No compartment stock owned.

e) 2) Suburban.
3) Metropolitan.

f) 1) Underframing and superstructure built as a whole.
2) Yes.

III. *Methods and materials used.*

a) 1) Steel.
2) Steel.
3) Steel.

b) 1) Underframe solebars, and bogie parts.
3) Bodies, longitudes and cross members.
4) Brackets, axleboxes etc.

c) Seat frames, seat handles, hand strap brackets, and generally all fittings and doors.

d) « Alpax » — Silicon-aluminium alloy.

e) Priming coat of paint.

f) 1) Copper chrome molybdenum steel.
3) Mild steel.
4) Mild steel.
5) Copper chrome molybdenum steel.

g) Does not arise.

h) 1) Riveting.
3) Riveted with steel rivets in light steel construction.

j) No experience of welding for this purpose. Two trailer bogies have been built up by welding, and are running under supervision.

l) Aluminium alloys for interior fittings.

m) Aluminium alloy fittings are approximately one third of the weight of the previous gun-metal ones.

n) The cost has been reduced by from 15 % to 20 %. These fittings are die-castings.

Great Western Railway.

The Great Western Railway Company (England) reply that it is not their policy to develop the construction of all new carriages in metal. They state :

« Our construction consists of body and roof being completely plated in steel carried on wooden framework; the interior partitions and fittings are mainly of wood.

The above practice is considered to be more satisfactory as being warmer in winter and free from condensation troubles, and is lighter and cheaper in construction than the steel coach, whilst being fire-proof from external fires which have sometimes occurred in accidents through the coaches coming into contact with fire from the engine from the outside. »

Africa.

Gold Coast Government Railway.

I. *General considerations.*

a) No.
b) Yes.
c) To ascertain, over a reasonable period, what comparative maintenance costs accompany the saving of tare weight per passenger.

II. *Progress and types.*

a) 14.4 %.
b) No.
c) No.
e)1) Main line.
f) 1) Body independent and entirely carried by underframe.

III. *Methods and materials used.*

b)1) Solebars, headstocks, crossbars, longitudinals and body framing.
2) None.
3) Bogie frame plates. Body side pillars.
4) Bogie centres, buffer guides.
c) Sunshades of 14-gauge aluminium, exterior panels, 14-gauge zinc, interior panels, 14-gauge zinc. Louvre frames of proprietary brand, silicon-aluminium alloy. Lavatory floors, Alpax aluminium castings. Lavatory walls, aluminium plates 1/16″.
d) Proprietary brand.
e) Teak packing.
f) 1) 13-gauge copper bearing steel.
2) 3/8″ « Agasote » millboard and 1/4″ « Sundeala » above waist rail, and 5/16″ « Sundeala » on ceilings.
3) 1/16″ steel plate.
4) « Induroleum » composition on 18-gauge galvanised dovetail pattern steel sheets.
5) 16-gauge copper bearing steel plates.

g) By « Agasote », « Sundeala » and « Celotex » sheets.
h)1) Riveting.
j) Such permanent joints as are smaller than necessary to accommodate riveting.
l) Lavatory floors and window louvres.
m) Negligible.
n) Negligible.

Kenya & Uganda Railways.

I. *General considerations.*

a) Not at present.
c) Considerable variation in temperature during day's run. Possible higher inside temperature on low lying sections of line. Difficulty of keeping in repair with African labour.

Nigerian Government Railways.

I. *General considerations.*

a) The standard third class coach seating 114 passengers is of steel. No definite decision regarding other classes of stock.
b) Yes, if maintenance is proved to be less costly than for wooden bodied stock. No information yet available regarding corrosion on account of climatic conditions. Workshops are better equipped at present to deal with repairs to wooden bodied stock.

II. *Progress and types.*

a) 16 %.
b) No, not at present.
c) No.

III. *Methods and materials used.*

b)1) Underframe members, bogie frames.
2) Cant rails, purlines, carlines, waist rails, waist rail channels, bottom sides, body angles, pillar and frame angles.
3) All pillars, floor bearers, waist rail top, miscellaneous framing, doorway, window frames.
4) Bogie side bearers, centre pin guide, buffer castings, spring cup and guide.
c) Window and louvre frames of alpax.
d) No detailed information re composition of « Alpax » frames.
e) None.
f) 1) Copper bearing and rust resisting steel.
2) « Sundeala » and « Agasote » millboard.
3) Wood panels with pressed steel framing and wood throughout.
4) Mild steel galvanised corrugated plates covered « Decolite » or « Induroleum » flooring composition.
5) Double wood sheeting, canvas covered.
g) Sunshade panels backed with « Celotex » asbestos sheeting. Inside casing and panels of « Sundeala » or « Agasote » millboard.

h)1) No information available. All-steel frame stock built in England.
2) No experience.
3) No experience.

j) No experience.

k) No information.

l) All fittings other than window and louvre frames of brass with oxidised copper and relieved finish, chromium plate finish and black oxidised finish.

m) No information.

n) « Alpax » window frames and louvres are 208 %, more expensive *in first cost* than wooden frames and louvres.

Sudan Government Railways.

I. *General considerations.*

a) No.

b) Yes, if the experience gained in connection with the vehicles now in service justifies the change in policy.

II. *Progress and types.*

a) 17 %.

b) No.

c) No.

III. *Methods and materials used.*

g) Asbestocel insulation.

h)1) Riveting.

Australasia.

New South Wales Government Railways.

I. *General considerations.*

a) No.

b) New suburban electric cars will be of all-steel construction.

c) As a precaution against fire; these vehicles run underground for portions of the journey.

II. *Progress and types.*

a) 67 % of electric cars are all-metal.
22 % of all passenger stock.

b) None contemplated.

c) No.

d)1) Existing all-steel cars have sliding doors at sides, two entrances on each side.
2) The existing all-steel cars are divided into three main compartments with sliding doors in the bulkheads and hinged doors at ends for passing from car to car.

e)2) Suburban railways (underground and surface.

f)1) and 2) Body and underframe combined in one structure.

III. *Methods and materials used.*

a)1), 2) and 3) Mild steel.

b)1) Underframe and bogies.
2) Nil.
3) The main transoms and underframe cantilevers, etc., are mild steel pressings. The body pillars, roof frames, etc., are all pressed from lead coated sheets.
4) Bolster spacers, drawspring stops, bearing spring brackets, centre castings, bolster spring seats and bolster buffer castings, axleboxes and horn cheeks on motor bogies.

c) Both the sliding and the hinged doors are aluminium alloy castings.

d) Copper min. 6 %, max. 8 %. Tin up to 1 %, remainder aluminium.
Tensile 9 tons per sq. in. min.
Elongation 3 % min.

e) No special precautions taken. Gun-metal fittings only are attached to aluminium alloy parts.

f) 1) Lead coated mild steel sheets.
2) Charcoal finish mild steel sheets.
3) Charcoal finish mild steel sheets.
4) Galvanised steel key section flooring and cork.
5) Lead coated mild steel sheets.

g) Sides, ends and roof are insulated by sheets of cellular asbestos attached to the inner surfaces of exterior panels.

h)1) Assembled in jigs and riveted.
2) Welding is used to a very limited extent in places such as corners of window openings to make them weatherproof.
3) Where interior linings or light weight fittings are secured with screws, hard grey fibre blocks are provided into which the screws are threaded. The fibre blocks are secured to the body framing with rivets. Generally mild steel rivets are used elsewhere.

j) Riveting is preferred for passenger coach body work, except in special cases, such as those mentioned, on account of liability to deformation.

k) No suitable comparisons are available regarding passenger carriages.

l) The frames of the ceiling lights are made of cast aluminium.

m) Comparisons are not available, as designs were not retained showing alternative metals or methods of construction. The specific gravity of the light alloy mainly used is 2.8. The cost of hauling the electric suburban cars over the system is approximately 1.8 pence per lb. weight of car per annum. This figure was used in determining whether it would be economical to use the light alloy.

n) No suitable direct comparisons available, but light alloy parts were not used, except where it was clearly economically sound.

New Zealand Government Railways.

I. *General considerations.*

a) No.
b) No.
c) As wood-working machines have been installed and New Zealand timbers are available, the introduction of all-steel carriage design is not at present justifiable.

India.

Eastern Bengal Railway.

I. — *General considerations.*

a) For the reason given under *c*), it is not our intention at present to develop the construction of all-metal carriages. The matter, however, is being investigated by the Railway Board, and the Consulting Engineers have been requested to submit preliminary designs of different classes for their approval.
c) Owing to the extreme humidity of the climate in Bengal, the oxidisation of the body framework and panel plates is very rapid.

II. *Progress and types.*

Types : 14 lower class carriages (4 inter and third and 10 third) are now on line. None under construction, nor in the process of being designed.
a) 0.62 %.
b) Not in the near future, unless ordered by the Railway Board.
c) No.

III. *Methods and materials used.*

j) This has not been tried, consequently no remarks can be offered.

East India Railway.

I. *General considerations.*

a) A decision has not yet been arrived at by the Government of India Railway Department.

II. *Progress and types.*

Types : 68′0″ B.G. Bogie stock.
a) 4.60 %.
b) No.
c) No.
e)1) Main line.
2) Suburban.
f) 1) Bodies independent of underframes.

III. *Methods and materials used.*

a)1) Steel, rolled sections, pressings.
2) Rolled steel sections and sheets.
b)1) Underframe members, carlines, and inner cant rails.
2) Outer cant rails.
3) Body pillars.
c) None in use.
f) 1) No. 12 S.W.G. steel sheet.
2) Wood.
3) Wood.
4) Sub-floor of dovetail pattern steel sheeting with composition top floor covered with linoleum.
5) No. 16 S.W.G. steel sheet.
g) Side and roof panels insulated with « Sundeala » asbestos millboard.
h)1) The vehicles we have in service are riveted.
3) Riveted with mild steel rivets.
j) No experience.
l) No.

Great Indian Peninsula Railway.

I. *General considerations.*

a) The general policy is directed by the Railway Board of the Government of India, and so far no such general policy has been indicated.
b) No.

II. *Progress and types.*

Types : Lower class vehicles of steel construction for both main line and suburban services are running. No new designs are contemplated.
a) 7.95 %.
b) No.
c) No.

Bengal Nagpur Railway and Madras and Southern Mahratta Railway.

Note. — The Bengal Nagpur Railway reply that they have no all-metal carriages, and the Madras & Southern Mahratta Railway reply that climatic conditions, and the lay-out of existing shops and plant do not justify the construction of all-metal carriages.

Ceylon.

Note. — The Ceylon Government Railway reply that they have had no experience with all-metal carriages.

Malaya.

Federated Malay States.

Note. — The Federated Malay States Railways reply that it is not their policy to develop the construction of new carriages in metal. The only vehicles so constructed are the standard Sentinel articulated rail motor cars, the behaviour of which will be watched with interest, but it is found that coach bodies of timber and steel constructed locally, are cheaper than those purchased from England, whether of steel or timber. The manufacture of steel bodies locally cannot be economically

undertaken. The climate of the Federated Malay States is very damp, and it is considered desirable to obtain experience with rail motor coaches mentioned above as to the extent corrosion may be expected before experimenting further with all-metall carriages.

Japan.

Japanese Government Railways.

I. *General considerations.*

a) Yes. Since 1926 all the cars newly built are of steel construction.
c) On account of safety, and for probable durability.

II. *Progress and types.*

Types : All new cars :
a) 19 %.
b) Yes. All the cars under construction are of all-metal type.
c) Yes. See under *f*.
d)1) Passenger cars on the steam roads have doors at ends only (closed vestibules). Postal and baggage cars and electric cars have large side doors.
2) No new cars are provided with compartment doors.
e)1) Yes.
2) Yes.
3) Yes.
4) No.
f) 1) No.
2) Yes. Our older steel cars were provided with fish-belly form centre sills to resist the end shock as well as to carry the total vertical load, but lately we adopted lighter centre sills built up of channels and plates, leaving the greater part of the vertical load to be carried by the side framing. Previously the car body has been of the « Monitor » type like American cars, but in future we shall adopt the single roof like that of European cars with a view to increasing the strength. On new cars in the electrified sections single oval roofs have been tried, and found to be satisfactory from the point of view of appearance.

III. *Methods and materials used.*

a)1), 2) and 3) Steel.
b)1) Most parts of underframe, body framing and bogie framing.
2) No special rolled sections used.
3) Posts and cross-bearers, and some girders.
4) Some members of the underframe and bogie frame.
c) Light metals have not yet been used for any members of structure because of the greater initial cost.
f) 1) Levelled steel sheets.
2) Ply-wood boards.
3) Ply-wood boards or wood boards.
4) Wood boards.
5) Wood boards covered with special thick asphalt-coated sheets. Ceiling, ply-wood boards enamelled.
g) Thick layers of hair felt are applied on the back face of steel panels, and the inside is finished with wood. (As electricity is used for lighting and steam for heating, there would be no fear of fire in case of accident.) Roof and ceiling of wood.
h)1) Riveting has been used for all joints, but on a number of cars, welding of panel plates to posts has been tried with good results. In the future, therefore, welding in this connection will be used to give a better appearance to the outside sheathing. Panel plates are joined to each other by welding.
h)2) By electricity or gas, according to circumstances in the works. As a precaution, most makers apply a piece of copper plate to the welded spot to lead away the heat during the process of welding. When any buckling or deformation of plate takes place, this is corrected by local spot heating with a burner, and quick cooling with water spray.
h)3) Light metals have not been used for structural members.
j) We have not yet attempted welding any joints other than the fixing of panels to the posts. We believe, however, in the future, welding of the underframe and truck frame members may be taken into consideration on account of weight saving.
l) With the exception of water tanks, handles and similar fixtures, which have been made for test purposes, but which have not proved satisfactory, we do not use light alloys.

Chosen Government Railways (Korea).

I. *General considerations.*

a) Yes.
c) Higher strength, comfort, safety, less repairing costs.

II. *Progress and types.*

a) About 3 %.
b) No.
c) No.
e)1) Yes.
2) No.
3) No.
4) No.
f) 1) No.
2) Yes.

III. *Methods and materials used.*

b)1) Underframe, roof ribs, etc.
2) None.
3) Pillars, cross-bearers, etc.
4) Centre sill fillers, striking blocks, end sill brackets and fillers, truck transoms, etc.

f) 1) Steel plate.
2), 3) and 4) Wood.
5) Steel plate, or wood and canvas.

g) Felt or cork lining.

h)1) Mostly riveting.
2) Electric welding for exterior panels, letter boards and other thin plate work. Gas welding for window moulds, side sills and side plate angles, etc. See sketch.

j) Yes. Lighter weight and better appearance.

China.

South Manchuria Railway.

I. *General considerations.*

a) It is our policy to construct all new carriages in metal.

c) Safety and durability.

II. *Progress and types.*

a) 31.45 %. (186 carriages.)

b) No.

c) Diesel-electric motor car. 3rd class trailer car. 3rd class gasoline car. Gas electric inspection motor car.

d)1) Doors are at both ends, except Diesel-electric motor cars, which have a door in the middle of the body.
2) None.

e)1) Main line.
2) Suburban.

f) Body and underframe are treated as one structure.

g)2) Body and underframe treated as one structure.

III. *Methods and materials used.*

a)1) Rolled steel and pressed steel.
2) Rolled steel and pressed steel.
3) Steel built up, or cast steel.

b)1) All parts of the body.
2) Not used.
3) Side posts and cross members of underframe.
4) Truck frames, truck bolsters, draft gear parts, centre plates, centre sill fillers, etc.

c) They are not used in ordinary carriages, but in some special carriages they are used for the following parts: Basket rack brackets, window blind fixture, grab handle of seat back etc.

d) No analyses are obtainable at present.

e) There are no such joints.

f) 1) Blue annealed and levelled steel sheets.
2), 3) and 4) Wood.
5) Steel sheets.

g) By lining exterior panels with plate-felt, by means of interior wooden panels, and by air space between them.

h)1) Rivets and electric welding.
2) Electric welding. To prevent local deformation, we apply a copper plate on the backs of the joints to dispel the heat.
3) No experience.

j) We consider welding is advantageous because it reduces the weight of the metal framing, but using welding for all joints needs further consideration. We use welding for all joints on the exterior panels with a view to facilitating painting and cleaning, and for some joints on the underframe.

k) No data available.

l) They are not generally used at present, but we are considering their use in the future.

m) No data available.

n) No data available.

APPENDIX III.

Summary of railway practices (Replies to questionnaire).

WAGONS.

Argentine.

Central Argentine Railway.

I. *General considerations.*

a) Yes.

c) Steel wagons have a longer life, and are less liable to damage.

II. *Types of metal construction.*

a)1) 43 % of covered wagons are of all-steel construction. 65 % of open wagons are of all-steel construction.
2) 10 % of covered wagons have steel underframes and body frames.

b)1) Body and underframe treated as one structure — High sided wagons fitted

with heavy centre sills.

2) Body is built up on the normal type of underframe suited to side buffing, and is fitted with a roof of galvanised iron sheets.

III. *Methods and materials used.*

a) Rolled steel sections.
b) No.
c) Lead paint.
d) None, other than spray painting.
e) Not considered necessary in this country for ordinary covered wagons. Perishable goods are carried in ventilated and insulated vans.
f) 1) Riveting.
g) Possibly. This matter will be given consideration when new wagons are ordered.

Buenos Ayres and Pacific Railway.

I. *General considerations.*

a) Yes.
c) Less maintenance.

II. *Types of metal construction.*

a)1) Open : 41.45 %. — Covered : 14.58 %. — Mineral : 86.75 %.
2) Open : 37.32 %. — Covered : 2.91 %. — Mineral : 13.25 %.
b)2) Covered wagons of 35-ton capacity, underframe built up of rolled steel sections etc., and has deep centre sills. The body pillars are « T » sections, and the outside panels are pressings in 5/64ths″ steel plates.
3) 35-tons hoppered ballast wagons are constructed with channel section side sills, the other members being of various rolled sections, pressings and plates.

III. *Methods and materials used.*

a) Steel 28/32-tons per sq. in. tensile.
b) No.
c) No.
d) No.
e) Louvre sides and end ventilation.
f) 1) Riveting and bolting.
2) Welding is not used.

Buenos Ayres Western Railway.

II. *Types of metal construction.*

a)1) Open merchandise (high sided) : 83 % type 1. 17 %, type 2.
2) Open merchandise (low sided) : 100 %, type 2.
Covered : 41 %, type 1. 49 % metal underframes and timber body.
Mineral : 100 %, type 1.
b) « Livesey-Gould » underframes built of rolled sections. Some frames built up of rolled sections and a few open wagons of pressings. Hopper wagons of pressed steel.

III. *Methods and materials used.*

a) Mild steel.
b) No.
c) No.
d) No.
e) No provision made. Special wagons used for perishable merchandise.
f) 1) Received riveted in assembled sections from builders.
2) Used only for joints of tanks on tank wagons — not used for framing. Oxy-acetylene.

Cordoba Central Railway.

I. *General considerations.*

a) Yes, as wooden stock becomes obsolete, and is retired from service, all-steel wagons are purchased to replace it.
c) Longer life owing to its ability to stand up to bad track conditions, and careless shunting. Parts can be quickly replaced from stock, and the period in shops under repair reduced. Bulged plates and other metal parts can be straightened and cracks electrically welded, thereby saving expense of new material.

II. *Types of metal construction.*

a)1) About 12 1/2 %.
2) The remainder have underframes of metal, and body frames of wood.
b)1) We have no all-metal open merchandise wagons.
2) Covered all-steel wagons of 35-ton capacity and average tare weight of 16.53 tons.
3) All-steel ballast wagons of 35-ton capacity and tare weight of 15.5 tons.

III. *Methods and materials used.*

a) The 35-ton covered wagons have riveted underframes. Frame longitudinals and headstocks are of mild steel channel 12″ × 3 1/2″ × 25.25-lb. per ft.
Sole bars of M.S. channel 8″ × 3″ × 15.96-lb. per ft.
Angle knees are of mild steel channel pressings, and corner gussets of 1/4″ mild steel.
b) A few all-metal covered wagons have the flooring made from the Armco iron product. Chemical composition unknown.
c) Gay's one-coat wagon paint. Composition unknown.
d) Spray painting.
e) No methods have been adopted.
f) 1) Frames are riveted with hand machines driven by compressed air.
2) Nil.
g) Not been considered.

United States of America.

Baltimore & Ohio Railroad.

I. *General considerations.*

a) Yes. Since 1928 all cars have been of the all-metal type with the exception that some of the gondola cars are equipped with wood floors and the box cars with wood floors and linings.
c) Increase of life and less maintenance cost.

II. *Types of metal construction.*

a)1) 38 % or 40 790 cars; 2 719 open cars; 38 071 hoppers.
2) 24 % or 26 530 cars with wood floors and lining: Steel frame — 10 568 open cars; 15 962 covered cars.
b) To make a car that will withstand the severe punishment to which they are subjected. Also the maintenance cost is found smaller on all-metal equipment than on either wood or composite cars.

III. *Methods and materials used.*

a) Copper bearing steel.
b) Yes.
Phosphorus not over 0.05 %.
Sulphur not over 0.05 %.
Copper not less than 0.20 %.
Tensile 50 000-65 000 lb. per inch².
Yield point min. 0.5 tens. strength.
Elongation in 8 in. min. % : $\frac{1\,500\,000}{\text{tens. strength}}$
c) We strive to use corrosion resisting material. The composition for freight car brown is:

	Max.	*Min.*
Pigment %	72	68
Raw linseed oil %	32	28
Moisture and other volatile matter %	1	—

d) The method adopted for the prevention of corrosion is to apply a coat of red lead on all sheets purchased for new work. Red lead is specified where metal is placed on metal and either riveted or bolted.
e) Our all-steel box cars are built with wood end and side linings with air space betweeen linings and outside metal sheathing. At first the cars were built with an opening between the roof sheet and side plate for ventilation. This did not prove very successful, and on recent cars this opening has been omitted.
f) 1) Rivets.
g) Welding can be substituted for riveting for all joints. The cost, however, is at present greater.
h) Approximately 10 %.

Delaware & Hudson Company.

I. *General considerations.*

a) No.
b) No.
c) We favour composite construction for the following reasons:
Lower maintenance costs.
Large portion of repairs can be made to composite cars at other than main shops.
Certain properties in coal cause corrosion to steel but do not affect wood.

II. *Types of metal construction.*

a)1) *All steel*: 9.66 % mineral.
2) *Steel frame*: 12.8 % covered; 54.8 % mineral.
b)3) The 55-ton hopper cars are of the side carrying type.

III. *Methods and materials used.*

a) Rolled and pressed copper bearing steel.
b) Yes.
Phosphorus:
Acid, not over 0.06 %.
Basic, not over 0.05 %.
Sulphur, not over 0.06 %.
Copper not less than 0.20 %.
Tensile 50 000-65 000 lb. per in.².
Yield point min. 0.5 tensile strength.
Elongation in 8 in. min. % : $\frac{1\,500\,000}{\text{tens. strength}}$
Elongation in 2 in. min. % : 25.
c) Yes. Red lead. (priming coat):

	Max.	*Min.*
Pigment %	84	80
Raw linseed oil %	20	16
Moisture and other volatile matter %	1	—

d) Yes.
e) We have no insulated all-steel cars.
f) 1) Riveting.
2) Welding not used.
g) Yes, to a large extent.
h) Estimated at about 12 %.

New York Central Railroad.

I. *General considerations.*

a) Yes.
c) Longer life, reduced maintenance, and safety of operation.

II. *Types of metal construction.*

a)1) 59.9 %.
2) 4.2 %.
We have no all-wood construction except a few isolated units scheduled for retirement. Information given above on wagons constructed entirely of metal refer to all-steel for open top wagons and all-steel except floors and linings for covered cars.

Floors and linings for covered cars are of wood.

b)1) Side carrying construction except high capacity gondola cars equipped with medium height sides and fish belly centre sills. These are of the side and centre carrying type.

2) Side carrying type.

3) Side carrying type.

III. *Methods and materials used.*

a) Centre, side, and end sills are of rolled structural shapes and plates. Bolsters, cross bearers, side and corner stakes are pressed steel plates.

b) A few mineral and open merchandise cars have been equipped with copper bearing steel sides for experimental purposes only. The copper bearing sheets used have the same physical and chemical properties as for ordinary soft steel plates except that they are required to contain a copper content of not less than 0.20 %.

c) Covered: All surfaces are thoroughly cleaned and outside surfaces of sides and ends and outside of all-steel roof (except galvanised roof sheets) are sand-blasted, after which one coat of priming paint is applied followed by two coats of finishing paint. Inside of sides and ends receive one coat of priming paint only. Both sides of steel doors receive one coat of priming paint followed by two coats of finishing paint on outside and one coat on inside. Underframes after being cleaned are given one coat of priming paint and one finish coat.

Open and mineral: Same procedure as above except only one coat of finishing paint is used. Insides are not painted.

d) Priming and finishing coats of paint are applied by spraying at majority of shops.

e) Sides and ends wood lined. No lining under roof sheets. Have conducted a number of tests with various methods of lining this part of car, but no standard of construction has as yet been adopted, or a decision reached as to the extent to which such applications if any, should be made.

f)1) Riveted construction.

g) We believe that as progress is made, welding may be largely substituted for riveting.

h) Based on information available as a result of experiments made by one of the leading car-builders in the construction of 70-ton capacity mineral car by welding process, it is believed that, as progress is made in the development of welded cars for general service, a weight saving of 10 % to 15 % can be obtained.

Norfolk & Western Railway.

I. *General considerations.*

a) All new cars will be built of all-metal construction on account of strength, durability, and cost of maintenance. Approximately 90 % are of that material now.

II. *Types of metal construction.*

a)1) Approximately 95 %.

2) Approximately 5 %.

b)1) We have open wagons for coal, ballast sand, mill materials and similar things.

2) We use covered wagons for merchandise, fruits, including grain.

3) Mineral wagons are of the open top type. In all cases we keep these general designs for the particular material to be carried.

III. *Methods and materials used.*

a) Largely rolled sections, channels, angles and « Z » bars.

b) We use almost entirely copper bearing steel, which we put in, in order to resist corrosion.

c) We use the best paint we know of in order to prevent corrosion.

d) All wagons are spray painted.

e) All-metal covered wagons are usually lined with wood. No special ventilation is provided except in particular instances where they are used for fresh fruits and vegetables.

f) 1) Riveting.

2) No welding is used.

g) We have never attempted the use of welding except for one tender tank, and we did not find that as cheap as riveting. This was the source of a great deal of trouble due to buckling of the sheets.

h) We have not done any of this yet, so we cannot say.

Pennsylvania Railroad.

I. *General considerations.*

a) Yes.

c) Safety, greater capacity and economy.

II. *Types of metal construction.*

a)1) 58 % open cars; 50 % covered; 100 % mineral.

2) 42 % open cars; 50 % covered; no mineral cars.

b) Body and underframe are treated as one structure.

III. *Methods and materials used.*

a) Open hearth steel.

b) Yes.

	Min.	*Max.*
Manganese	0.30	0.60
Copper	0.20	—
Phosphorus	—	0.06
Sulphur	—	0.06

Tensile strength 50 000 lb per in.[2]. Yield point 0.5 tensile strength. The tension test will not be required for plates or sheets 1/4″ and under in thickness, nor for shapes under 1 sq. inch in cross sectional area.
c) No.
d) No.
f) 1) Mostly riveting.
2) Gas.
g) Yes, all joints.
h) No record.

Reading Company.

I. *General considerations.*

a) Yes.
c) Greater strength, longer life and freedom from repairs.

II. *Types of metal construction.*

a) 1) 62 % open cars; 21 % covered; 100 % mineral cars.
2) 38 % open cars; 79 % covered; no mineral cars.
b) The underframe and body are built as one unit with heavy centre sills.

III. — *Methods and materials used.*

a) Structural steel.
b) Yes. In roof sheets.
American Railway Association specification for « sheet steel and thin plates » with copper (when ordered) not under 0.20 %.
c) A good commercial red lead.
d) Only in so far as paint spraying has been substituted for paint brushing.
e) Hair felt insulation.
f) 1) Riveting.
g) Yes.
h) None.

Wabash Railway.

I. *General considerations.*

a) All mineral wagons of the hopper type are of all metal.
b) Yes.
c) Reduced cost of maintenance.

II. *Types of metal construction.*

a) 1) Open and covered cars : none. Mineral : 100 %.
2) Open cars, 50 %; covered, 51 %; mineral, none.
b) Built up of steel plates and shapes with heavy centre sills.

III. *Methods and materials used.*

a) Open hearth steel.
b) In some cases for trial.
c) Black asphaltum cement on underframes.
d) Yes.
e) We have no all-metal covered wagons.
f) 1) Riveting.
g) Yes.
h) Have had no experience.

Canada.

Canadian National Railways.

I. *General considerations.*

a) No.
b) Yes.
c) To utilize the material most common in the country, we use a composite type of steel and wood.

II. *Types of metal construction.*

a) 1) 4.97 %. — Open cars : 22.77 %; covered : 0.20 %; mineral : 100 %.
2) 58.43 %. — Open cars : 42.43 %; covered : 62.64 %; mineral : none.

III. *Methods and materials used.*

a) Rolled steel shapes and plates.
b) Yes, in some cases copper bearing.
c) No, oxide or red lead.
d) No.
e) Do not insulate.
f) 1) Riveting.
2) No.
g) No.
h) Nil.

Canadian Pacific Railway.

I. *General considerations.*

a) Yes, excepting such as flooring and lining.
c) Traffic conditions, which require cars of ample strength for movement in heavy main line trains at increasing speeds.

II. *Types of metal construction.*

a) 1) 17 %.
2) 40 %.
b) 2) See drawing.

III. *Methods and materials used.*

a) Standard rolled sections, with open hearth steel plates.
b) Yes, copper bearing steel (specif. No. 104) :
Carbon not over 0.25 %.
Manganese not over 0.60 %.
Phosphorus not over 0.05 %.
Sulphur not over 0.06 %.
Copper content not over 0.20 to 0.30 %.
c) No, surfaces of sheets are sand-blasted and primed.
d) No.
e) Box cars have wood side and roof lining, the inner sides of steel sheets have a layer of heavy sawdust applied on paint paste.
f) 1) Jigs used.
2) Electric welding.
g) In general, yes.

Great Britain.

Great Western Railway.

I. *General considerations.*

a) No.

b) Our practice in regard to open goods wagons is to make the floor and sides of timber carried on an iron or steel underframe.

c) The wooden bodies are preferred to steel ones by our Goods Department.

II. *Types of metal construction.*

a)1) Open: Metal frames and body framework with wood sheeting: 96 %.
Covered: Metal frames and bodies with wood floors: 26 %.
Metal frames and body framework but wood sheeting on floors: 37 %.
Mineral: Metal bodies and frames: 79 %.

b) Body and underframe treated as one structure.

III. *Methods and materials used.*

a) Grade « B » iron for open wagons, steel for covered wagons, grade « B » iron for mineral wagons.

b) Twenty-five 12-ton open goods in 1928, of iron substitute.
Twenty-five 12-ton open goods in 1928 in copper bearing steel.
Fifty 20-ton coal wagons built in 1930 in copper bearing steel.
Composition of copper bearing steel is as below:

Combined carbon	0.142 %
Silicon	0.058 %
Manganese	0.724 %
Sulphur	0.030 %
Phosphorus	0.016 %
Arsenic	0.035 %
Chromium	Absent.
Nickel	Trace.
Vanadium	Absent.
Copper	0.288 %

Physical tests.

Breaking stress, tons per in.²	29.2
Elongation in 2″, %	37.0 %
Reduction of area, %	60.4 %
Yield point, tons per in.²	16.7
Ratio: Yield point to ultimate stress	57.3 %
Brinell hardness No.	121

c) Oxide paint used, of following composition:

Metallic oxide	74 %
Turpentine substitute	9 %
Boiled linseed oil	11 %
Driers	6 %

d) No.

e) By fitting end ventilators.

f) 1) All details jig drilled and riveted.
2) One open goods only electrically welded for experimental purposes.

g) Insufficient experience.

h) Insufficient experience.

London Midland & Scottish Railway.

I. *General considerations.*

a) We are experimenting, but have not yet sufficient information as to costs etc., to decide what our policy is to be.

II. *Types of metal construction.*

a)1) Hopper coal, coke and ore wagons also all special vehicles such as well-trollies required for heavy and bulky loads.
2) Covered goods, ventilated meat vans.

b)1) Built of rolled steel channels, angles and plates, also a few minor pressings where they can be conveniently and economically used.
2) Constructed as above, and outside steel body construction. The interior is lined with wood.
3) 12-ton underframe and body of timber. 20-ton and upwards, all steel construction, but old type.

III. *Methods and materials used.*

a) Mild steel.

b) Yes, to a limited extent, and chiefly as an experiment.
Composition as follows:
Copper, 0.30 to 0.35 %.
Sulphur, not more than 0.060 %.
Phosphorus not more than 0.060 %.
Round test piece turned parallel for 4 1/2 times the diameter and tested on a gauge length equal to 4 times the diameter.

Tensile test.

Grade.	*Maximum stress, tons per sq. in.*	*Elongation, minimum %.*
1.	28—32.	24.
2.	24—28	32.

c) Yes.

Pymrut (red oxide of iron)	65 %
Boiled linseed oil	30 %
Liquid driers	5 %

d) No.

e) Inside linings of casing boards with air-space between them and the outer metal sheeting.

f) 1) Members are assembled in a jig, and riveted each to each by rolled angle knees and bent plate knees.
2) No welded joints used.

g) Have no experience, but is now the subject of experiment.

h) We cannot say.

London & North Eastern Railway.

I. *General considerations.*

a) No.
b) Yes, to a limited extent, according to the commodity to be carried.
c) The Company's shops are better laid out to deal with the building and repairing of timber constructed wagons.

II. *Types of metal construction.*

a)1) Open: 0.067 %; covered: nil; mineral: 2.11 %.
2) Open: 17.97 %; covered: 12.18 %; mineral: 2.06 %.
b)1) The wagon is constructed with the underframe designed to carry the load, and to take all buffing and draw stresses.
2) No all-metal covered wagons.

III. *Methods and materials used.*

a) The materials used are mild steel to British Standard Specification No. 18*a*, report No. 24 dated 1929.
b) No.
c) Yes, anti-corrosive red paint used for first coat on all-metal wagons, and first coat on metal underframes and metal framed bodies.

Composition by weight.

Red oxide, dry	60.0 %
Linseed oil, boiled	26.0 %
Liquid dryers	8.0 %
Turpentine substitute	6.0 %

d) No.
e) This does not apply, as we have no all-metal covered wagons.
f) 1) Joints or connections are made by means of angle or plate knees, gusset plates and riveting.
2) Do not use welded joints.
g) No experience; the whole question requires consideration and trial. An experimental private owner's wagon is now running on this system, and is being carefully watched.
h) No experience.

Africa.

Gold Coast Government Railway.

I. *General considerations.*

a) No.
b) Yes.
c) Ease of renewal and repair in Colony.

II. *Types of metal construction.*

a)1) Open: 46.4 %; covered: 57.5 %; mineral: 37.7 %.
2) Open: 12.3 %; covered: 30.6 %; mineral: 62.3 %.
b) Underframes are of fishbelly type and are built up of steel pressings. Pressed steel plates are used for the sides. On both open and covered wagons the floor is of wood.

III. *Methods and materials used.*

a) Mild steel pressings and plates.
b) No.
c) Metallic paint (Tayler's « Silvereen » Brand).
d) No.
e) Provision of ventilators.
f) 1) Riveting.

Kenya & Uganda Railways.

I. *General considerations.*

a) With the exception of cattle wagons and cold storage cars, *yes.*
c) All-metal wagons were originally adopted and have proved satisfactory. No attempt to construct them in wood.

II. *Types of metal construction.*

a)1) Open: 100 %; covered: 95 %; mineral: —.
2) Open: Nil; covered (cattle): 5 %; mineral: —.
b) Open and covered wagons have underframe and body as one structure, centre sills being of heavy section to take buffing and draw shocks. On bogie wagons, fish belly underframe with pressed steel main members is used.

III. *Methods and materials used.*

a) Mild steel.
b) No.
c) Yes. Red « Danboline ». Composition not known.
d) Spraying is done with red « Danboline ».
e) Nothing has yet been done in this connection.
f) 1) Riveting.

Nigerian Government Railways.

I. *General considerations.*

a) No definite decision yet made. Wooden-bodied vehicles will be required for certain classes of traffic.
b) Yes, for certain traffic only.
c) Workshops are better equipped to deal with repairs to wooden bodied stock. Steel bodied vehicles, for certain classes of traffic are subject to corrosion and expensive maintenance.

II. *Types of metal construction.*

a)1) Open: 7.9 %; covered: 11.3 %; mineral: 10.7 %.
2) Open: 6.8 %; covered: 32.3 %; mineral: 31 %.

b) All wagons are of bogie type. Bodies are constructed of steel plates, either galvanised or pressed steel, and are riveted to the underframe which is built up of rolled steel sections.

III. *Methods and materials used.*

a) Mild steel sections. Body plates of mild steel or galvanised in the case of some classes of covered wagons.
b) « Corrostite » steel has been used experimentally for curb rails on wooden bodied covered goods stock. No results yet available.
c) « Torbay » anti corrosive used.
d) No.
e) No special methods except ventilators on ends of body.
f) 1) Steel stock built in England. No information available.

Sudan Government Railways.

I. *General considerations.*

a) Yes.
c) The steel wagon withstands the climate and rough usage better.

II. *Types of metal construction.*

a) 1) Open: 100 %; covered: 93 %; mineral; —.
2) Open : —; covered : 7 %; mineral : —.
b) Open and mineral wagons have body and underframe built as one unit. Underframe is construction of standard rolled steel sections. Covered wagons are similar in construction, but have roofs of corrugated galvanised sheets. The floor is of sheet steel.

III. *Methods and materials used.*

a) Steel.
b) No.
c) No.
d) No.
e) Nothing done on wagon stock.
f) 1) Riveting.

Australasia

New South Wales Government Railways.

I. *General considerations.*

a) With the exception of floors, all open, flat and mineral wagons will be entirely of steel. Underframes and body framing of cattle, sheep and louvred vans will be of steel.
b) See reply to *a*).
c) Reduced maintenance costs.

II. *Types of metal construction.*

a) Open : 83 % entirely of metal.
Covered : None entirely of metal.
Mineral : 51 % entirely of metal, 49 % underframes and body framing of metal.
b) Open : Underframe and body framing combined in one structure.
Covered : Underframe and body framing combined in one structure.
Mineral : These are constructed mainly with separate hopper bodies which can readily be lifted out of the underframes.

III. *Methods and materials used.*

a) Rolled steel sections and plates.
b) No. On a few ballast hopper wagons, « Keystone » copper bearing plates have been used for the bodies, but the experience is not yet sufficient to determine the increase in life.
c) Only experimentally.
d) No, only experimentally.
e) This railway system has no all-metal covered wagons.
f) 1) Assembled in jigs and riveted.
2) Electric; bare wire electrode.
g) Experience to date is insufficient to warrant expressing an opinion.
h) No suitable comparisons are available.

New Zealand Government Railways.

I. *General considerations.*

a) The policy is to develop the construction of all new *open* wagons entirely in metal.
b) See reply to *a*).
c) For the class of goods for which these wagons are used it has been found that the all-steel construction is more suitable and the cost of maintenance less than those previously built in wood.

II. *Types of metal construction.*

a) 1) 34 %.
2) None.
b) Open : Rolled steel channel section underframe, body of plates and angles.
Covered : None.
Mineral : None.

III. *Methods and materials used.*

a) Rolled steel channel and angle sections and plates.
b) No.
c) For underframes : Coal tar.
For bodies : Red oxide paint, composed as follows :
5 gallons red oxide (Nelson N. Z. product).
3 pints terebene.
1 gallon boiled oil.
3 pints turpentine.
d) No.
e) None.
f) 1) Riveting. Special jigs are made upon which the frames are assembled and riveted.
2) No joints welded.

g) Welding can be substituted for riveting in the assembly of all-metal vehicles for all joints and angle attachments, except the heavy castings, such as draft lugs.
h) No appreciable reduction in weight.

India.

Eastern Bengal Railway.

I. *General considerations.*

a) Our policy is to follow the designs adopted by the Central Standards Committee appointed by the Railway Board. It may be added that these designs are all-metal wagons.

II. *Types of metal construction.*

a)1) Practically all the wagons constructed during recent years are entirely in metal.
b) All-metal open and covered wagons are constructed with the box formation of underframe and the side and end panels are riveted to the body stanchions which in turn are riveted to the underframe. For mineral wagons the underframe is made as above, and the body (a shell) is riveted to a cradle.

III. *Methods and materials used.*

a) Steel channels, angles, and mild steel panel plates.
b) No.
c) Yes. Anti-corrosive « Bitumastic » black paint supplied by Messrs. Robert Kearsley & Co., composition not known.
d) No.
e) No such steps have been taken.
f) 1) Riveting.
2) Welding is not used.
g) This has not been tried on this Railway consequently no remarks can be offered.

East Indian Railway.

I. *General considerations.*

a) Yes, also all-steel goods brake vans have been standardised.
c) Life of a mild steel wagon in this country is approximately 33 % longer than one constructed with timber, and maintenance charges are considerably less.

II. *Types of metal construction.*

a)1) 99 % of wagon stock entirely constructed of metal.
2) 1 % of wagon stock with metal underframes and body framing. These consist of open wagons which are used for general purposes. These wagons, when they have reached their economic life will be replaced by all-steel wagons.
b) The underframes are constructed of rolled steel sections, and the bodies are built up of mild steel angles, plates and flats, and are built as one unit with the underframe.

III. *Methods and materials used.*

a) Mild steel channels for underframes and mild steel angles for bodies.
b) No.
c) A good quality oil paint is sprayed on the wagons.
d) No.
e) The difference in temperature between a timber body and a steel body is not sufficient to warrant the provision of any form of insulation.
f) 1) Riveting, except in the case of oil tank wagons, the barrels of which are lap-welded.
2) Electric welding.
g) No experience with regard to underframe and body members.

Great Indian Peninsula Railway.

I. *General considerations.*

a) This has been the policy in India for many years.

II. *Types of metal construction.*

a)1) All
b) An underframe of rolled steel sections, framing steel angles, steel sheeting with sheet or corrugated iron roofs. Standard wagons follow the designs of the Railway Board.

III. *Methods and materials used.*

a) Mild steel rolled sections.
b) No.
c) No, ordinary paints ground in oil.
d) No.
e) It can be proved that the temperature in a steel wagon is little more than that of a wood vehicle if both are ventilated. Perishable goods, parcels and livestock are conveyed in steel or wood vehicles ventilated.
f) 1) Riveting.
2) Not tried.
g) Not tried.
h) Not tried.

Bengal Nagpur Railway.

I. *General considerations.*

a) Yes.
b) No.
c) All metal wagons have proved satisfactory in service, and less expensive to maintain than wood or part steel and wood wagons.

II. *Types of metal construction.*

a)1) 98 %.
2) Nil.
Open merchandise : 1 296; covered : 7 694; Mineral : 13 269.
b) The underframe is the girder.
Steel sides do not act as girders.

Outer members are girders with cross inner longitudinal bearers.

III. *Methods and materials used.*

a) Steel channels, angles, « U » sections, bulb angles and steel plates.
b) No.
c) Bituminous paint and coal tar are used.
d) No.
e) No heat insulation is used. Ventilators, hoods at either end.
f) 1) Riveting.
2) Welding is only used for repairing cracked members. The electrode arc system is employed.
g) We have no experience.
h) Not known.

Note. — The Madras & Southern Mahratta Railway Company reply that all their wagons are constructed entirely in metal, but on the question of policy, they are dependent upon the Railway Board, and the « Indian Railway Standards » wagon designs, and consider that an expression of individual opinion on these matters would be of no value.

Ceylon.

Ceylon Government Railway.

I. *General considerations.*

a) Yes.
c) Decreased first cost and maintenance charges.

II. *Types of metal construction.*

a) 1) Open merchandise : 23 %; covered : 42 %; mineral : —.
2) Open merchandise: 71 %; covered: 31 %; mineral : —.
b) The underframes are built up of standard rolled sections, channels etc., the body frames are of rolled steel angles, with outside sheeting of galvanised iron, or sheet steel.

III. *Methods and materials used.*

a) Steel. Tests are now being carried out with bogie coal wagons constructed entirely of wrought (puddled) iron and wrought (ingot) iron against steel constructed wagons.
b) No experience with these.
c) Lead base paints are used exclusively for protecting steel work .
d) No experience.
e) By fitting louvred ventilators.
f) 1) Riveting.
2) No experience with welded joints.
g) No experience.
h) No experience.

Malaya.

Federated Malay States Railways.

I. *General considerations.*

a) With the exception of certain types for which timber is considered to be more suitable, it is our policy to develop the construction of all-metal wagons.
c) Steel underframes are superior to wood in withstanding excessive draft and buffing shocks. Galvanised iron or steel plate is used for the construction of bodies, and is found to withstand the corrosive effect of the climate, and requires less attention than the timber bodies.

II. *Types of metal construction.*

a) 1) Open merchandise, 37 %; covered : 86 %; mineral : 36 %.
2) Open merchandise : 2.6 %; covered : 2.6 %; mineral : 2.6 %.
b) Both open and covered wagons are built as single structures. The four main longitudinal members of the underframe are 9″ × 3 1/2″ rolled steel channels.

III. *Methods and materials used.*

a) Steel.
b) Copper bearing steel has been used experimentally in the underframes of cattle wagons, but the chemical composition of the material is not known.
c) No special paints are used.
d) No.
e) Metal bodies are not usually used for vehicles in which heat and condensation are important factors, but where metal has been used, the body is double lined, leaving free air spaces. Insulating materials such as « Celotex » have occasionally been used.
f) 1) Steel wagons are manufactured in England, and riveting is used exclusively.

Japan.

Japanese Government Railways.

I. *General considerations.*

a) Yes, with the exception of the roofing of box cars and drop sides of open cars which are made of wood.
c) For safety, and protection against rain leakage in the case of box cars. Wood boards are used for the roofing of box cars to prevent the heat accumulation inside, and for drop sides of open cars (gondolas), where rain leakage is not feared, and stiffness is required.

II. *Types of metal construction.*

a) 1) 10.1 % or 6 741 wagons.
2) 38.1 % or 25 516 wagons.

	Number.	Total.	Per cent
All-steel body :			
Box cars A . . .	649	6 741	10.1
Flat cars J . . .	225		
Coal cars	5 867		

	Number.	Total.	Per cent
Steel-framed body :			
Box cars B (steel sheathed) . . .	1 943	25 516	38.1
Box cars C (steel sheathed) . . .	3 964		
Box cars D	9 079		
Refrigerator and fish cars . . .	473		
Gondola cars G . .	8 362		
Flat cars	1 821		

b) The standard open (gondola) car is constructed with a steel underframe and side frame, and wood hinged sides. The standard « box » car is constructed with a steel underframe and body framing, steel outside sheathing; wood roofing and flooring with wood inside lining. Coal cars are exclusively of all-steel construction.

III. *Methods and materials used.*

a) Chiefly standard rolled sections. Cross-bearers are of pressed steel.
b) Copper bearing sheet is now used only for inside water-proof lining and ice tanks on refrigerator cars (ceiling ice tanks, unique design on our cars). When the corrosion test on copper bearing steel, now going on at our Research Institute is proved satisfactory, more extensive application may be considered. Copper content not less than 0.20 % is specified.
c) No, only ordinary paint.
d) Sherardized bolts and nuts exposed to the weather are now under test.
e) By having roof and inside lining made of wood boards.
f) 1) Riveting, chiefly.
   2) Electricity or gas, according to circumstances.
g) For some joints only.

Chosen Government Railways (Korea).

I. *General considerations.*

a) Our policy regarding all-metal wagons is not fixed at present, but we are making experiments with some wagons made entirely in steel.
c) Durability of metal parts, especially steel plates is not yet confirmed.

II. *Types of metal construction.*

a) 1) 1.3 %.
   2) Open : 12.4 %; covered : 5.7 %.
b) In all-steel mineral hopper wagons, the body and underframe are built as one structure with heavy fish belly type centre sills. The 30-ton covered wagons are constructed with body and underframe as one unit, with heavy centre sills. The body framing, outside panels and roof are all of steel, and the floor and inner lining are of wood.

III. *Methods and materials used.*

a) Steel plate, and rolled steel section.
b) Not yet.
c) No.
d) No.
e) Wood lining only.
f) 1) Riveting.
g) Yes, for some joints only according to our present experience.

China.

South Manchuria Railway.

I. *General considerations.*

a) Yes.
c) From the standpoint of solidity, strength, durability, and immunity from fire and water.

II. *Types of metal construction.*

a) 1) 1 926.
   2) 2 469.
b) With the exception of tank cars, the body and underframe are treated as one structure.

III. *Methods and materials used.*

a) Rolled steel, pressed steel, and cast steel.
b) « *Armco* » *steel sheets :*

Carbon	0.054
Silicon	0.01
Manganese	0.04
Phosphorus	0.011
Sulphur	0.035
Copper steel sheets :	
Carbon	0.15
Silicon	0.02
Manganese	0.26
Phosphorus	0.012
Sulphur	0.029
Copper	0.178

c) Red lead paint, one layer (red lead 67 %, white lead 11 %, boiled linseed oil 15 %, turpentine 7 %).
   Black paint, two layers (barium sulphate 41.5 %, boiled linseed oil 48 %, carbon 2.1 %, turpentine 8.4 %).
d) No.
e) The roof is lined with fibre boards, and the interior panels are made of wood.
f) 1) We assemble by riveting.
   2) Electric welding.
g) We consider it advantageous to use welding as far as possible.
h) No data available.

[621. 138]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XIIth SESSION (CAIRO, 1933).

QUESTION IV:

Methods to be used to increase the mileage run by locomotives between two repairs including lifting.

REPORT No 3.

(All countries except America, Great Britain, Dominions and Colonies, China, Japan, Germany, Denmark, Finland, Norway; Spain, Netherlands, Portugal and their Colonies, Sweden and Switzerland),

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I. — Repairs including lifting.

The necessity for the repair of a locomotive which includes lifting depends principally upon the state of the parts which can only be repaired after lifting off the wheels.

Such parts are the following :

a) The wheels and in particular the tyres;

b) The bearings and axle boxes and the hornchecks;

c) The frame;

d) The boiler.

The wear and condition of these parts depends upon the type of locomotive (weight, wheel base), the nature of the service (speed, use made of the locomotive), the character of the lines (curves, gradients, length of the rails), the attention to and normal maintenance of these parts in service, as well as the quality of the materials employed.

Apart from exceptional cases (wheel fractures or loosening of the tyres), a locomotive has to be lifted owing to tyre wear. This tyre wear is produced either perpendicularly to the axis of the wheel, or parallel to that axis and should not exceed a predetermined limit. The most frequent reason for lifting ordinary and express passenger locomotives is the condition of the bearings. The premature wear of the bearings and hornchecks is due to insufficient lubrication, to careless maintenance in service (tightening up the wedges) or to the previous repair having been badly done (carelessness in arriving at the standard dimension). Frame defects are comparatively rare if the dimensions of the plates are proportional to the weight of the boiler. The boiler is given a thorough repair when the locomotive is lifted, if the boiler has to be examined or if it is necessary to lift the locomotive soon after the boiler is given a general repair.

The inspection of locomotive boilers is the subject of legislative provisions in *Belgium, France, Luxemburg, Poland, Italy, Rumania* and *Czechoslovakia.* The inspection periods are fixed in terms

of the time elapsed. In regard to the inspection of the running gear, brake, etc., only the service regulations are in force except in *Bulgaria*, where there is a statutory prescription concerning the brake.

Most Administrations carry out the repairs done when lifting after a predetermined length of run, expressed in locomotive-kilometres or train-kilometres, whereas boiler repairs are done at the end of a prescribed interval of time. In *Bulgaria*, however, locomotives are repaired at intervals of about 30 months. In addition, the *North of Milan* Railway repairs its passenger locomotives every two years and its goods and shunting locomotives every four years. The mileage laid down may be exceeded if the state of the boiler is good and the fuel consumption satisfactory. The *French Est* Railway makes special arrangements for its express locomotives which are repaired every year, between the 1st October and the 1st May, so that in Summer a sufficient number of express locomotives in perfect condition are available. The same procedure is followed in Czechoslovakia.

The mileages vary with the types of locomotive. The following table shows the minimum distances run in kilometres between two repairs of a locomotive.

ADMINISTRATION.	Passenger locomotives.	Goods locomotives.	Shunting locomotives.	*Remarks.*
Belgium	80 000	60 000	40 000	
P.-L.-M.	60 000	35 000 to 50 000		
French Est	65 000	50 000	38 000	With former working method.
Do.	90 000	75 000	...	With new working method.
Paris-Orleans	75 000 to 90 000	60 000 to 75 000	60 000	
French State	65 000 to 75 000	55 000	...	
Alsace-Lorraine	45 000 to 75 000			
Damas-Hamah	20 000 to 40 000			
Luxemburg	125 000	120 000	...	Provisional indications.
Czechoslovakia	No minimum mileage prescribed.			

The boilers are generally inspected at the end of a specified period. Some administrations make a distinction between the internal and the external inspection of the boiler, while others do not.

On the *French Est* there is a periodical inspection at the end of eighteen months and a ten-yearly inspection. At the periodical inspection it is not necessary to demolish the brick arch nor to remove the lagging. At the ten-yearly inspection, the boiler has to be opened up completely and all tubes removed. When the repair is completed, the boiler undergoes a hydraulic test.

On the *Paris-Orleans* Railway, the boilers are inspected at the end of twelve to eighteen months, no distinction being made between external and internal inspections. On the Paris-Lyons-Mediterranean Railway the boiler is inspected when the locomotive is lifted. The firebox and the accessible parts of the boiler are principally inspected. A complete inspection of the boiler takes place every eight years. This examination is chiefly due to the wear of the firebox tube plate, which receives the following repairs : at the end of 2 years, any broken bridges of the tube plate are welded; at the end of 3 years the holes in the tuble plate are bushed; at the end of 4 years the drilled portion of the tube plate is renewed, and the above-mentioned operations are repeated.

The *Smyrna-Cassaba* Railway is obliged to inspect the interior of the boiler each time the locomotive is lifted, on account of the bad quality of the feed water.

In Italy, no distinction is made between the external and internal inspections. According to law, these two inspections must be carried out simultaneously. A heavy repair is carried out every 6 years. During the intermediate repairs, the boiler is not lifted out of the frame. The firebox is inspected on this occasion. If the tubes are withdrawn, the boiler barrel is inspected at the same time.

The *Polish State* Railways have the boilers inspected internally when undergoing heavy repairs. After repair the boiler undergoes a pressure test. External inspections are made on the occasion of the intermediate repairs done when the locomotive is lifted.

In *Egypt,* no distinction is made between the external and the internal inspections.

On the *Czechoslovakian State* Railways the boilers are inspected externally every year and thoroughly every 6 years. During the annual inspection the firebox is examined and tested for leaks. The same applies to the arch tubes, stays, tubes, rivets and roof stays. The sides are examined to see they have not become deformed. In order to remove the scale from the boiler, the necessary number of tubes are withdrawn. The other parts of the boiler which are accessible without dismounting are inspected. On the occasion of the six-yearly inspection, all the tubes have to be renewed and the boiler has to be tested for tightness hydraulically.

In the case of the *French Est Railway,* the following work is done systematically when repairing a locomotive during the periodical inspection with takes place every 18 months : withdrawal of at least 10 bottom tubes with a view to cleaning the boiler shell; caulking of leaks; scraping firebox plates; complete clearing of stay holes and fittings of the tube plate; checking the thickness of the firebox plates after removal of a sufficient number of stays; cleaning the inside of the boiler by scraping and washing; renewing fusible plugs; painting accessible internal parts with animal black; painting visible external parts with red lead No. 1. During a repair which coincides with the 10-yearly test, the following additional work is also carried out systematically : all the tubes are taken out; the boiler is hammered inside; the boiler is scraped on the outside; the boiler is painted completely inside and outside.

On the *Paris-Lyons-Mediterranean* Railway (*P. L. M.*) in addition to the above-mentioned repair of the firebox tube plate, the tubes with damaged ends are replaced. The stays with worn heads are also removed. Worn roof stays are dealt with in the same way. Finally corroded places are welded electrically and parts of the boiler which require it are reinforced. The *Paris-Orleans* Railway has all the tubes welded to the steel tube plates. On the *French*

Nord, the tube plate of the firebox is always renewed during heavy repair.

The *Belgian National* Railways regularly replace the bottom plate of the smoke box and do the same for the fire door plate. The *Thessaly* Railways attach special importance to the use of scale-preventing preparations, and washing with hot water under pressure and take advantage of every opportunity of carrying out small maintenance repairs, thereby obviating serious damage. The *Smyrna to Cassaba* Railway emphasizes the importance of straightening the tube plates. The *Damas-Hamah* Railway replaces the defective boiler by a spare boiler, so that the locomotive is able to leave the shops in a short time.

In Italy, the main repair of a boiler involving lifting it out of the frame is only done in the central workshops. The boiler is carefully cleaned and is inspected by a committee appointed by the Government, and this committee suggests to the shop manager the repairs which ought to be carried out. The manager examines the suggestions and passes them on to the rolling stock and locomotive running department headquarters which makes the final decision. The following repairs may be involved : replacement of the firebox, and smokebox tube plate, the firebox back plate, etc. The boiler is repaired in three to four weeks. The boiler is not removed for the intermediate repairs carried out in the depot shops. The tubes, bolts, rivets are renewed and the firebox plates, etc., are welded. At each heavy repair and also each intermediate repair, all the cocks and valves as well as all the feed water and safety fittings are dismantled and repaired.

In *Poland* at each heavy repair (inspection of the interior of the boiler) the tubes are renewed and the boiler is thoroughly cleaned and completely repaired. The firebox is renewed at the end of 20 years of service. In *Czechoslovakia*, the annual inspection is made without removing the boiler. The defective tubes, stays and rivets are renewed, leaks caulked, cracks welded and patches put on if necessary. The fittings are inspected and tested. At the 6-yearly inspection, the boiler is removed from the frame and all the defective tubes and if necessary the plates are renewed. If need be the firebox or the whole of the boiler is renewed.

II. — Periodic inspections.

During the time a locomotive is in service, the following work is carried out regularly by the various administrations :

In *Egypt* the inspection of the cylinders and slide valves, renewal of piston rings, inspection of the fittings.

In *Belgium* the prescribed minimum mileage (40 000 km. [24 855 miles] for shunting locomotives, 60 000 km. [37 285 miles] for goods locomotives, 80 000 [49 710 milles] for passenger locomotives) run between two repairs is divided into 8 sections. Certain parts are inspected at the end of each of these sections. Thus for example, after the second section (1/4 of the prescribed mileage), the following parts are inspected : axle box wedges, slide valves (without withdrawing the pistons) injectors, exhaust steam feed water heater, mechanical lubricators, fusible plugs, couplings, continuous brake, spark arrester. On the *Damas-Hamah* Railway, periodical inspections as such of the locomotive parts are not made while the locomotive is in service. The locomotive is kept in good condition by the running repairs, in accordance with reports made by the drivers and the inspectors. Certain special equipment (cylinder lubricators, locomotive and tender draw gear) are inspected when the boiler is washed out.

The *French Est* divides the periodical inspections of the parts into inspections

on a time basis and inspections on a mileage basis :

A. — **Inspections on a time basis.**

Monthly : clack boxes, tanks and water strainers, locomotive and tender draw gear;

Bi-monthly : drain cocks, blast pipe, spark arrester, rods on single expansion express locomotives, starting gear fusible plugs of express locomotives;

Three-monthly : all feed water equipment, fusible plugs of all other locomotives;

Six-monthly : Westinghouse brake parts, pressure gauges, boiler valves.

B. — **Inspection on a mileage basis.**

a) In the case of locomotives repaired under the old methods :

After half the mileage : Bogie axle box keeps of express locomotives.

After 1/3 and 2/3 of the mileage : Pistons, valve gear and high pressure drain cocks, lubricator strainers.

b) In the case of locomotives repaired under the new methods :

After 1/2 the mileage : Bogie axle box keeps of express locomotives, low pressure valve gear, pistons and valves, high pressure valve gear, pistons and drain cocks, lubricator sieves of all locomotives.

After 1/4, 1/2, and 3/4 of the mileage : Valve gear, pistons, drain cocks, lubricator strainers on the express locomotives.

On the *Paris-Lyons-Mediterranean* (*P. L. M.*) the periodical inspection covers overhauling of all moving parts, i. e. pistons, slide valves, rods, valve gear, wheels and axles, spring gear, brake and the blast pipe.

In *Algeria* (*P. L. M.* System) an inspection is made after half the mileage. On compound locomotives with superheater, all the moving parts working under high pressure are also inspected after a quarter of the mileage.

On the *Paris-Orleans* (*P. O.*) the following inspections are made between two general repairs of the locomotives :

1. *After half the mileage :* Pistons, valves, driving rods, valve gear, test cocks, gauge cocks, pressure gauge steam cock, screw couplings, fusible plugs.

2. *For « special fittings »* the following rules are applied :

a) Locomotives :

Every 2 months: Injectors, feed water heaters, compressed air brake, air-pump cylinder and valves, air-pump pressure regulator piping, coupling hose pipes, screw brake of the tender, speed indicator, signal repeating apparatus, locomotive and tender draw gear.

Every 3 months : Separator of feed water apparatus.

Every year : Regulator.

b) Tenders :

Every 2 months : Screw brake.

Every three months: Washing out and inspection of the water tanks.

French State Railways :

1. The locomotive examiners inspect the locomotives daily on their arrival in the depot and before their departure therefrom.

2. On the occasion of washing out : The locomotive inspectors examine the mechanism, and a foreman boilermaker inspects the firebox and smoke box.

3. *Every month :* Blast pipe, draw gear, ash pan, wheels, tyres.

4. The boiler feed apparatus and the brake are tested every month.

5. *Every 6 months :* The air pump and air pump valve gear, recording apparatus.

6. The pistons and slide valves are inspected as follows : flat slide valves after 15 000 km. (9 320 miles), piston valves after 30 000 km. (18 640 miles).

Alsace-Lorraine Railways :

Every month : Spark arrester, ash pan with trap door.

Each time locomotive is lifted : Superheater header and elements.

Every 2 months : Speed indicator and signal repeating apparatus, boiler feed equipment.

Every 3 months : Injectors, fusible plugs, driver's brake valve, firebox, intermediate locomotive and tender coupling.

Every 6 months : Safety valves, air pump, brake cylinders, main brake pipe.

The high and low pressure pistons and valves, and the by-pass valves and the release cocks of the brake cylinders or the valve gears are inspected after a predetermined mileage. The same applies to cleaning the feed water heaters and to the superheater joints.

French Nord Railway : In addition to being examined when lifted, locomotives are also inspected at regular intervals. The periods depend upon the type of locomotive and apply to inspections of the valves and pistons, the taking up of play in the connecting rod brasses, the brake gear, etc. An annual whole line programme is only drawn up for repairs done when the locomotives are lifted.

Italy : Whilst the locomotives are in service, the following work is carried out : 1. Ordinary running repairs; 2. Lifting and intermediate repairs.

The periodical inspection of the brake cylinders, connecting rod brasses, etc., is carried out at the time of the intermediate repairs. All this work is carried out in accordance with programmes drawn up every 6 months and checked by headquarters.

The period between 2 general or medium repairs is determined by headquarters in proportion to minimum mileages for each type of locomotive and for each depot, the nature of the line and of the feed water being taken into consideration.

Jugoslavia : Regular inspections take place according to the following programme :

Monthly : Draw and buffer gear, valve spindles of certain types of locomotive, water pipes between the locomotive and tender, stays, tubes, wash-out hole bolts and covers, smoke box, smoke box door, spark arrester, ash pan, accessories, lighting set.

Three-monthly : Fusible plugs, steam chests, water gauges, test cocks, speed indicator, brake injectors, clack box, connecting and coupling rods and their brasses.

After 20 000 to 30 000 km. (12 430 to 18 640 miles) : Cross heads, steam cylinders, valve gear, pressure gauges, safety valves, brake, tyres (condition and wear).

After 40 000 to 60 000 km. (24 860 to 37 280 miles) : Hand brake, bogies, main frames, springs, by-pass valve, superheater.

After 80 000 to 100 000 km. (49 720 to 62 140 miles) : Locomotive lifted if a repair has not become necessary earlier due to tyre wear.

Administration of Indo-China :

Monthly : Fusible plugs, locomotive and tender intermediate coupling, ash pan, spark arrester, blast pipe, feed water heater, tender wheel sets.

Bi-monthly : Continuous brake and hand brake, speed indicator.

Three-monthly : Pistons and valves, crank pins on heavy locomotives.

Six-monthly : Safety valves, pressure gauges, live steam pipes.

Luxemburg : The pistons of superheated steam locomotives are examined every 8 months, the piston valves and the piston valve spindle packings every 3 months, the mechanical lubricator every 6 months, its strainer every month. The examination periods for the other parts vary between 1 and

4 months. In addition, quite a number of parts are examined during washing out.

Poland :

a) *Every 3 months :* Fusible plugs, couplings, boiler feed apparatus, pistons, valves;

b) *Every 6 months :* Pressure gauges, safety valves, brakes, spark arrester;

c) *Every year in autumn :* the steam heating.

Rumania :

Monthly : Locomotive and tender intermediate draw gear;

Bi-monthly : Fusible plugs, connecting and coupling rods, cranks, cross heads, tyres, axle brasses of passenger locomotives.

Six-monthly : Safety valves, pistons and valves, cylinders, injectors, mechanical lubricator, bogie or truck (without taking down), pressure gauges, superheater dampers, brake, axle brasses of goods locomotives.

Yearly : Exterior inspection of boiler, regulator, taking down bogie or truck, speed indicator, steam heating, repainting inside of tender.

Bi-yearly : Lifting the locomotive and tender, axles, wheels, axle box brasses (or alternatively after 100 000 km. (62 140 miles), superheater.

Five-yearly : (in the central workshops) : Interior inspection of the boiler.

Smyrna-Cassaba Railway : Examination of the pistons and valves after 30 000 km. (18 640 miles). On locomotives employed on lines with gradients of 1 in 40, the first and the second coupled axles are interchanged after 30 000 to 40 000 km. (18 640 to 24 860 miles). Examination of the regulator every 3 months; of the brake every 6 months; firebox top, staying, every month. All this work is done by the depot staff.

Czechoslovakia : The different parts of locomotives are examined periodically at the following intervals :

Monthly : Locomotive and tender intermediate draw gear.

Three-monthly : Fusible plugs.

Six-monthly : Pistons, valves, valve gear, motion, boiler, feedwater and lubrication fittings, brake, speed indicator. This examination may be postponed 6 months if the locomotive is otherwise in good condition.

Bi-yearly : Lifting, if the tyres are worn more than 6 mm. (1/4 inch) on the head, or more than 8 mm. (5/16 inch) on the flange, or if the condition of the locomotive demands it. This normal period is shortened or extended according to the actual state of the locomotive.

* * *

Most of the Administrations are of the opinion that the effect of carrying out intermediate repairs is to increase the mileage between two lifts (general repairs). It is impossible to express in figures this increase in mileage because it depends upon many other factors (type of locomotive, nature and intensity of traffic, etc.).

It is estimated to be from 20 to 50 %. Some Administrations (for example the *Alsace-Lorraine* and the *Damas-Hamah* Railways) consider that by means of intermediate repairs the locomotives are maintained in better and cheaper working order and untoward incidents in service are prevented as dangerous cracks and other defects of the various parts are discovered, but that no increase in the mileage through carrying them out can be counted on between two general repairs, in view of the fact that this mileage also depends upon the condition of parts which cannot be ascertained without lifting the locomotive.

* * *

The repair shops carry out the following work on locomotives in service :

In *Italy :*

a) medium repairs, that is to say lifting the locomotive without removing the boiler. On this occasion the mechanism is examined.

b) examination of the locomotive parts without lifting. This work is effected between two repairs including lifting.

c) running repairs required by drivers or ordered by the depot foreman.

The *French Nord :* Ordinary lifting of the locomotive and heavy repairs.

On the *French State :* Almost all the depots lift the locomotives and carry out all maintenance work.

On the *French Est :* Overhauling of boiler mounting joints, renewing piston rod packings, replacing stays, adjusting and fitting of connecting and coupling rod brasses, renewing springs, replacing brake blocks, cleaning the boiler feed fittings, reconditioning brake and lubrication pipe unions. In rare cases : Expanding tubes and replacing them, re-making the superheater elements joints at the header, replacing superheater elements, returning worn axle journals, turning tyres with worn flanges (on long wheel base locomotives working on mountainous lines).

In *Czechoslovakia :* The repair shops carry out all periodical inspections and all repairs of a secondary character required in service, such as :

a) Stopping leaks at flanges, stuffing boxes, tubes, ash pan dampers, and smoke box doors;

b) taking up the play produced by a leak (valve gear bushes, stuffing boxes, wedges, liners);

c) reconditioning the pressure gauge, boiler mountings, valves and brake;

d) straightening bent parts (rods, plates, fire bars);

e) replacing worn or defective parts (springs, brake blocks).

f) repairing rod brasses which have been hot. Examination of axle keep boxes, lubricators, injectors, etc.

* * *

On most of the railways, the locomotive enginemen do no repair work. On other railways they make repairs to a limited extent, when the repairs in question do not require any special technical knowledge nor special tools. Such repairs include remaking pipe unions, oiling, tightening bolts and adjusting wedges.

* * *

Special gangs of fitters for night work are only employed on the *Alsace-Lorraine Railways* and in *Rumania.* The other administrations do not employ night gangs. The most urgent work is done by from one to three fitters at the most. In the most urgent cases the foremen can bring a gang of fitters for night duty in exceptional cases.

The number of workmen required in the depots is calculated as follows :

P. L. M. : The number is proportional to the mileage and the type of locomotives assigned to the depot, each locomotive having a maintenance coefficient.

Belgium : The number of hours of maintenance work for 1 000 km. run has been fixed according to the type of the locomotives, so as to take into account the method of construction of the boiler and of the mechanism of each type. The mileage run in one month represents a number of working hours according to which the number of workmen required in the following month is fixed. In regard to dividing this number up between the different trades, the machine tool equipment, the boiler work required, and the size of the depot are taken into consideration.

Paris-Orleans : The importance of the various jobs has been determined by timing the different operations. In a depot for which the monthly mileage is 500 000 km. (310 700 miles) on level lines, the number of workmen employed is as follows :

Number of labourers	18
Number of workmen	179, namely :
Erectors	100
Fitters	26
Turners	13
Machinists	10
Boilersmiths	15
Coppersmiths	3
Smiths and helpers	4
Autogenous welders	3
Electric welders	1
Electric fitters	2
Painters	2

French State : The number of workmen required is fixed in the following manner: — A maintenance coefficient is determined for each type of locomotive. The effective mileage of the locomotives of each type of a depot are multiplied by the corresponding maintenance coefficients and the total represents the total virtual mileages of each of the depots. The number of workmen required for running repairs and for special work is proportional to the average daily virtual mileage and the number of workmen required for the lifts is proportional to the virtual mileage between two repairs (according to the average for the previous 12 months).

Alsace-Lorraine :

Group I. — Current maintenance (actual running repairs; periodical examinations; various alterations; inspection of the fire boxes; stays; reconditioning fittings; examining boxes running hot; outside work) :

$$\frac{2.5\ PK}{1000}.$$

Group II. — Intermediate repairs (gangs of fitters for repairing locomotives and tenders) :

$$7\ n\ c\ K'.$$

Group III. — Firebox work (boilersmiths and helpers for repairs to the firebox in daily routine service and at the intermedite repairs :

$$0.18\ \left(\frac{2.5\ PK}{1000} + 7\ n\ cK'\right).$$

Group IV. — Special work (lathes and machine tools); fitters' work; coppersmiths' work ; autogenous welding ; Westinghouse brake; steam heating; injectors; boiler feed apparatus; lubricators; valve and cocks; speed indicator :

$$0.30\ \left(\frac{2.5\ PK}{1000} + 7\ n\ cK'\right).$$

Group V. — Miscellaneous (joiners, painters, brick arch layers, tinsmiths, smiths, electricians, etc.) :

$$0.20\ \left(\frac{2.5\ PK}{1000} + 7\ n\ cK'\right).$$

Total :

$$\left(\frac{4.2\ PK}{1000} + 11.76\ n\ cK'\right).$$

Explanation of symbols :

P = average daily distance run (in kilometres) for the depot and its auxiliary services, based on the preceding six months. This calculation includes a coefficient for each type of locomotive.

K and K′ = coefficients for each depot depending on its layout, the number of engines and difficulties in carrying out repairs (K for the current maintenance repairs, K′ for the intermediate repairs).

n = monthly average number of locomotives repaired during the last six months.

c = average coefficient of these locomotives.

Damas-Hamah: According to the mileages run by the locomotives and taking into consideration the mileages run by the locomotives between two lifts or between one lift and a general repair :

	Standard gauge.	Narrow gauge.	
	One skilled workman per :		
		Adhesion.	*Rack.*
Erector	40 000 km. (*24 860 miles*).	50 000 km. (*31 070 miles*).	20 000 km. (*12 430 miles*).
Boilersmith . . .	60 000 km. (*37 280 miles*).	40 000 km. (*24 860 miles*).	40 000 km. (*24 860 miles*).
Turner	70 000 km. (*43 500 miles*).	70 000 km. (*43 500 miles*).	35 000 km. (*21 750 miles*).

Italy : The number of skilled workmen required is determined according to the average annual mileage of the locomotives assigned to the depot, this determination being made separately for the different types of locomotives.

Poland : The tradesmen and workmen work on day work with premiums.

Egypt : According to the number of locomotives repaired daily.

French Nord : The number of workmen in the shop is determined from the number of hours allowed for the current maintenance of each type of locomotive, according to the number of lifts and of heavy repairs to be done by the shop.

Jugoslavia : The monthly repair costs are taken out, the labour (A) and materials (B) costs being shown separately. About 10 % is then deducted for the unskilled workmen and the remainder is divided by the average monthly remuneration of a skilled workman. This gives the number of skilled workmen necessary for the maintenance of locomotives of a given type.

Czechoslovakia : The locomotives are divided into ten groups according to the importance and the extent of the repair work each requires. In these groups there are certain definite units of repair for each kind of repairs. The permanent nucleus or effective strength of the staff is fixed according to these units. The kind of repairs depends directly upon the mileage. The ordinary running repairs alone depend upon the defects and failures which occur daily. The various repair shops are provided with the tool equipment found necessary by experience, and the staff is distributed among the different trades according to the tools available.

* * *

With regard to the question as to whether the work is done by piece work or by day work, it should be mentioned that piece work is used on the following railways : *French Nord, P. L. M., Alsace-Lorraine, P. O.,* and the *French, Bulgarian, Italian, Jugoslav and Czechoslovakian* State Railways. On the *French Est,* the workmen receive a fixed wage and in addition an individual premium.

For each workman, this premium is proportional to the time employed in carrying out the various jobs for which a time allowance has been fixed by timing. In the other administrations, the fitters only are paid by the day.

III. —Minor repairs (inspections).

During the regular lifting, all the administrations also make an examination of the pistons, valves and other locomotive parts. However the practice of turning the tyres between two lifts has not been generally adopted. As a rule this is only done at the time the locomotive is lifted. The *P. O.* rounds the flanges of the front wheels by means of a special device mounted on the locomotive, the effect of which is to prevent the formation of sharp flanges.

Light repairs are generally carried out in the running shed shops.

* * *

The time required for carrying out a minor repair including re-turning the tyres is very variable and depends upon the nature of the repair. The repair takes at least three days. Some administrations (such as for example the *Alsace-Lorraine,* the *French State,* the *P. O.,* the *Czechoslovakian State* Railways) do not carry out *light* repairs when lifting the locomotive. Ordinary lifting during which all the necessary repairs are done, takes from 3 to 40 days according to the amount of repairs involved.

Some administrations are of the opinion that the mileage between two general repairs including lifting can be considerably increased (up to as much as 50 %) by means of light repairs. The examination of the pistons and valves prevent any regular increase of fuel consumption until the regular lifting of the locomotive. Some administrations, on the contrary, do not, in principle, carry out light repairs.

* * *

The administrations were asked to reply to the following question :

How do you proceed when it becomes necessary to carry out a locomotive repair including lifting 6 to 9 months before the periodical inspection of the boiler and when you know by experience that, before this inspection, there will be insufficient wear to justify further repair with lifting.

The replies received state that generally care is taken that the boiler is repaired at the same time as the engine is lifted. When the case mentioned in the question arises, the solution adopted consists in putting forward the date of the inspection of the boiler and the repair, or the locomotive is lifted and any essential repairs are carried out.

* * *

Generally there are no special rules for the bogies or bissel trucks and the carrying wheels and axles. The *P. L. M.* alone inspects the bogies after half the mileage which has to be made after lifting. In addition, the same railway inspects the carrying wheels after 10 000 km. (6 215 miles). Some Administrations devote particular attention to the bogies and carrying wheels by frequently checking the wear of the tyres. *Bulgaria* recommends inspection of the bogies and carrying wheels and axles every 6 months, especially on express locomotives. Bogies and carrying wheels are taken down at the same time as all the other running gear of a locomotive.

* * *

On most of the railways it is customary to interchange the various wheels sets of the locomotive, unless constructional reasons prevent this. This exchange is effected when carrying out repairs between two lifts and makes it possible to get uniform wear of the tyres until the next lift.

* * *

The next question was worded as follows :

What in your opinion are the parts of the locomotive, the maintenance of which has the greatest influence on increasing the mileage ?

The replies show that conscientious maintenance and lubrication of the axle boxes and the wedges and also the rational maintenance of rod brasses have the greatest importance from this point of view.

* * *

IV. — Materials, design, etc.

The supplies of locomotive tyres and of rails are governed in regard to the materials used by the following technical specifications :

COUNTRIES OR ADMINISTRATIONS.	Rails.		Tyres.	
	Minimum tensile strength, kgr./mm² (*Engl. t. per in².*)	Elongation, %.	Minimum tensile strength, kgr./mm² (*Engl. t. per in².*)	Elongation, %.
Belgium	68 (*43.2*)	12	78 (49.5)	11
France	65 (41.3)	10	70 (*44.4*)	14
Italy	...	...	75 (47.6)	14
Jugoslavia	...	...	70—92 (44.4—58.4)	8
Luxemburg	65 (41.3)	...	78 (49.5)	11
Poland	70 (44.4)	10	80 (50.8)	7
Rumania	90 (57.1)	...	75 (47.6)	...
Czechoslovakia	80 (50.8)	...	75 (47 6)	...
Damas-Hamah	72 (45.7)	9	70 (*44.4*)	14
Smyrna-Cassaba	72 (45.7)	9	70 (44.4)	15

The administrations are generally of the opinion that it is desirable to employ harder material for the rails than for the tyres, seeing that renewal of the tyres is less expensive than that of the rails. Still, with the sole exception of the *P. O.*, no railway has carried out investigations and tests on these lines. According to the experience of the *P. O.*, the use of hard steels for the rails and tyres gives good results on level lines. The tyres are only renewed at the end of 300 000 to 400 000 km. (186 400 to 248 600 miles), corresponding to a length of service of 4 to 5 years. The rails on lines with heavy traffic last up to 30 years. On lines with small radius curves, the *P. O.* has employed rails and tyres of steel, having a tensile strength of 90 kgr. per mm² (57.1 Engl. t. per in²). In addition, this railway has provided, in the case of locomotives running on these lines, lubrication by means of the device described in the *Revue Générale des Chemins de fer*, 1929. The result is that the tyres need only be renewed at the time of the general repair. No abnormal rail wear has been observed. The other Administrations (for example the *Czechoslovakian State* Railways) are also studying this type of apparatus, but for the mo-

ment are confining themselves to isolated trials.

The following table shows the maximum wear of tyres :

COUNTRIES OR ADMINISTRATIONS	Minimum thickness of tyres mm. (*inches*).	Description of locomotives	Maximum permissible wear of flange, mm. (*inches*).
Belgium	30-35 (*1.18-1.38*)	According to tyre fastening.	5 (*0.197*)
Bulgaria	25 (*0.98*)	All locomotives.	...
Damas-Hamah	35 (*1.38*)	Do.	...
French Est	44.5 (*1.75*)	Express locomotives.	...
Do.	39.5 (*1.55*)	Goods locomotives.	...
Do.	36.5 (*1.44*)	Branch line locomotives.	...
Do.	33.5 (*1.32*)	Passenger locomotives.	...
P. L. M	40 (*1.57*)	Braked wheels.	...
P. L. M.	35 (*1.38*)	Unbraked wheels.	...
Alsace-Lorraine	30 (*1.18*)	All locomotives.	...
French State	40 (*1.57*)	New locomotives.	...
Do.	35 (*1.38*)	Old locomotives and shunting locomotives.	...
French Nord	45-25 (*1.77*)	According to class of locomotives and line.	3-5 (*0.118-0.197*)
Italy	32 (*1.26*)	All locomotives.	5 (*0.197*)
Jugoslavia	25 (*0.98*)	Do.	5 (*0.197*)
Rumania	25 (*0.98*)	Do.	...
North of Milan	35 (*1.38*)	Do.	...
Smyrna-Cassaba	20 (*0.79*)	Do.	...
Poland	30 (*0.79*)	Do.	5-7 (*0.197-0.276*)
Paris-Orleans	30 (*0.79*)	Carrying wheels.	5 (*0.197*)
Do.	35 (*1.38*)	Coupled wheels.	...
Do.	40 (*1.57*)	Coupled wheels of heavy locomotives.	...
Greece	30 (*0.79*)	All locomotives.	...
Czechoslovakia	40-30 (*1.57-1.18*)	Depending on wheel diameter.	6 (*0.236*)

The tyres are renewed when the thickness of the tyres is reduced by turning to a carefully predetermined dimension. On some railways the same rules are applicable to all locomotives. On others a distinction is drawn between the tyres of locomotives or the methods of fastening the tyres, sometimes also between the wheel diameters or according as to whether or not the axles are braked. The necessity for returning the tyres is governed by the wear of the flanges.

* * *

The question as to whether tests have been made with a view to ascertaining what tyre profile is most suitable for giving the highest possible mileage has received a negative reply from the railways consulted.

* * *

The Administrations were asked what types of stuffing boxes have proved satisfactory on superheated steam locomotives and have involved the least expense and work. The information received is recorded in the following table :

COUNTRIES OR ADMINISTRATIONS.	Stuffing boxes in service.	Stuffing boxes on trial.
P. L. M.	...	Metal packing. (*Pb* 80 %, *Sb* 20%) ; Garex.
Alsace-Lorraine	Schmidt type with rings (*Pb* 80 %, *Sb* 20 %).	Hauber, Huhn.
Alsace-Lorraine	Schmidt type with rings (*Pb* 65 %, *Cu* 35 %).	...
French State	Schmidt.	Hauber, Garex, Est.
P. O.	Hauber.	...
Belgium	Crescent.	...
Italy.	Metal packing.	...
Bulgaria	*Pb* 74 %, *Sb* 16 %, *Sn* 10 %.	Huhn.
Rumania	Sack-Kisselbach.	Huhn, Kreissinger.
Luxemburg	Sack-Kisselbach.	...
Jugoslavia	..	Huhn, Hauber.
French Nord	White metal packing.	...
Smyrna-Cassaba	Cerex.	...
Czechoslovakia	Hauber, Huhn, Schmidt.	...

The best results are obtained, according to the reply by the *French Est*, with labyrinth metal packings. The *P. O.* replies that since the adoption of Hauber metal stuffing boxes instead of white metal stuffing boxes formerly used, the costs per 1 000 km. have dropped from 23 fr. to 13.50 fr. for goods locomotives (four cylinders, 1 372 H. P., eight packings).

* * *

The axle boxes and rod brasses are generally made of bronze (so as to get 80 % to 90 % copper with added zinc and lead). The *P. L. M.* adds a fairly large proportion of lead.

The white metal employed for lining the brasses is of two kinds : it contains either a considerable proportion of *Sn* (tin alloys) or a preponderant proportion of *Pb* (lead alloys). The tin alloys are employed most frequently. The composition of a tin alloy is as follows : 75 to 83 % *Sn* and 10 to 15 % *Sb*; the rest is copper or lead. In the lead alloys, the greater proportion of the tin is replaced by lead and their composition is as follows : 64 to 85 % *Pb*, 2.2 to 15.5 % *Sn*, 9 to 15.5 % *Sb*. A white metal with a greater lead content (98.61 %) is being tried in Poland. This alloy does not contain any tin. In *Belgium*, a certain number of bearings are employed without lining metal. The following table (see pages 1554 and 1555) gives particulars regarding the composition of the brasses and white metal employed by the various Administrations.

* * *

According to the experience of most of the Administrations, the mileage between two lifts is influenced by feed water of poor quality. A bad feed water involves the necessity for frequent running repairs, such as caulking tubes and stays. In addition, the life of the tubes is shortened. To soften the feed water, chemical products (soda, lime) are added to it, or mechanical means are employed for this purpose to prevent the formation of hard scale, such as the Neckar (*Bulgaria*), Peck-Rejtő, Schmidt-Wagner (*Rumania*), Vesely, Vorisek-Stepan (*Czechoslovakia*). These devices have stood the test. Good results have also been obtained with electrical apparatus (Pulso-Ekonomisator).

Other Administrations, on the other hand, are of the opinion that bad feed water has no influence on the mileage. They consider that the mileage between two lifts is not influenced by the quality of the water.

* * *

The properties of the lubricating oils employed on some Railways are given in the following table A (pages 1556 and 1557) and the lubricators used in table B (page 1558).

* * *

Mechanical lubricators as a rule are only employed for the lubrication of the pistons and valves. On new locomotives, they are also employed for the lubrication of other parts, particularly the axle box bearings. According to the replies received, mechanical lubrication affords the following advantages over displacement lubrication :

1. Reliability of working in service;
2. Saving of oil (up to 50 %) resulting from the fact that lubrication is only operative when running;
3. Simplification of the work.

The advantages of the mechanical lubrication of the axle boxes are the same, although the saving in oil is usually still greater.

* * *

The lubrication of the tyre flanges or rail heads has not been generally adopted. It is principally employed on mountain lines. The *P. L. M.* is experimenting with a device which only lubricates the inner face of the rail heads and only on curves. On the lines in mountainous districts the *French State* has adopted the lubrication of the tyre flanges on one locomotive in two, the effect of which has been to reduce the abnormal wear of the tyres to such an extent that the mileage between turning the flanges formerly only 20 000 km. (12 430 miles) now exceeds 40 000 km. (24 860 miles). The *P. O.* lubricates the wheel flanges of locomotives for moun-

COUNTRY OR ADMINISTRATION.	Composition of brass metal							Remarks.
	Cu	*Sn*	*Zn*	*Pb*	*Ph*	Impurities.	Waste bronze.	
French Est	84-86	12-14	...	...	...	2	...	...
Do.	...	...	...	...	...	...	...	...
Paris-Lyons-Mediterranean	77	6	...	17	...	2.5	...	...
Do.	...	...	...	...	...	...	...	...
Alsace-Lorraine	86	14	...	...	...	...	..	...
French State	86	14	...	...	...	...	...	...
Do.	90	10	...	...	...	...	...	...
P. O.	90	8	2	...	...	...	...	...
Belgium	78	10	...	10	...	2	...	...
Do.	90	6	4	...	...	...	...	...
Bulgaria	84	15	1	...	...	...	...	...
Poland	...	...	...	...	...	...	...	...
Do.	...	...	...	...	...	...	...	...
Do.	...	...	...	...	...	...	...	...
Do.	..	...	...	...	...	...	...	...
Do.	...	...	...	...	...	...	...	...
Luxemburg	17.5	...	0.63	...	...	...	81.87	Axle bearings.
Do.	15	...	1.25	..	...	...	83.75	Rod bearings.
Smyrna-Cassaba	42.5	6.5	1	...	...	...	50	...
Damas-Hamah	85.7	12	2	...	0.3	...	...	...
Italy	83	16	0.5	0.5	...	...	...	...
Do.	...	...	...	...	...	...	...	...
Egypt	...	...	...	...	...	...	...	...
Jugoslavia	...	..	...	...	...	...	...	...
Do.	...	...	...	...	...	...	..	...
French Nord	86	14	...	..	...	...	...	...
Greece	...	...	...	...	...	...	...	...
Czechoslovakia	80	9	8	3	...	...	...	...

Composition of white metal.								Waste white metal.	Remarks.
	Sb	*Cu*	*Ni*	*Pb*	*Na*	*Li*	Impurities.		
83	10.5-11	5.5-6	...	...	...	...	1	...	Depending on class of locomotives.
5	9-10	...	...	84.85	...	...	1	...	
.5	15.5	2.5	2.5	64	...	...	1	..	For driving wheels of all locomotives, for coupled wheels of express locomotives and for rod bearings.
5	10	...	...	85	...	...	1	..	For locomotive and tender carrying wheels.
3	11	6	...	...	...	...	...	...	...
3	11	6	...	...	...	...	...	..	...
.	...	...	...	...	...	...	...	...	...
)	12	7.7	...	...	...	...	0.3	...	...
thout white metal lining.				...	...	...	...	...	...
ied with white metal.				...	...	...	...	...	...
3	8	4	...	...	...	...	...	..	...
37	15.30	2.3	...	58.82	...	...	0.21	...	For axle and rod brasses.
.6	11.78	1.6	...	80.1	...	...	1.06	...	For parts of secondary importance.
2	17.91	0.54	...	76.7	...	...	1.33	...	Bondrat metal for axle and rod brasses.
23	15.2	0.49	...	80.3	...	...	1.78	...	Bondrat metal for parts of secondary importance.
.	...	0.732	...	98.61	0.619	0.039	...	..	On trial.
3	13	5	...	60	...	...	...	4	...
.	...	...	...	...	...	...	...	...	..
5	15	10	...	...	...	...	...	...	...
3	11	6	...	...	...	...	...	...	...
3	11	6	...	...	...	...	...	..	For brasses under high specific pressure.
4	10	...	...	76	...	...	...	...	For brasses under low specific pressure.
)	10	5	...	5	...	...	...	...	...
)	12	6	...	2	...	...	...	...	For standard gauge locomotives.
)	13	5	...	12	...	...	...	..	For narrow gauge locomotives.
3	11	6	...	...	...	...	...	...	...
3	11.1	5-6	...	...	...	...	...	..	...
5	15	10	...	...	...	...	...	...	...

TABL

COUNTRY OR ADMINISTRATION.	Oil for superheated steam cylinders.										C			
	Density at		Flash point, Deg. C. (Deg. F.)	Freezing point, Deg. C. (Deg. F.)	Viscosity at				Asphalt.	Soap.	Density at		Flash point, Deg. C. (Deg. F.)	Freezing point, Deg. C. (Deg. F.)
					(Barbey)		(Engler)							
	15° C. (59° F.)	20° C. (68° F.)			100° C. (212° F.)	200° C. (392 F.)	75° C. (167° F.)	100° C. (212° F.)			15° C. (59° F.)	20° C. (68° F.)		
French Est . . .	0.906	...	270 518)	9 (48)	146	...	...	...	0.30	1.41	0.941	...	180 (356)	-6 (21.2)
French Est . . .	0.906	...	291 (556)	7 (45)	110	...	...	...	0.34	7.87	...	...	...	...
French Est . . .	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Alsace-Lorraine .	...	0.900	270 (518)	...	176	...	...	...	0.20	...	0.87-0.93	...	260 (500)	-10 (14)
Alsace-Lorraine .	...	0.904	305 (669)	...	148	...	...	...	0.36	...	...	...	...	...
Alsace-Lorraine .	0.910	...	305 (669)	...	110	...	...	...	...	...	...	...	...	...
P. O.	0.904	...	297 (586)	...	93	790	...	...	...	...	0.905	...	290 (554)	...
P. O.	0.910	...	320 (608)	...	73	672	...	...	...	. .	...	...	...	...
P. O.	...	...	...	...	...	...	...	...	...	...	...	. .	...	. .
P. O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Belgium	0.900	...	255 (481)	...	...	...	12.5	1.95	0.5	3.5	0.925	...	225 (437)	...
Bulgaria	...	0 95	300 (572)	...	...	...	...	5-7	0.1	...	...	0.960	270 (518)	...
Poland	0.920	...	310 (590)	5-6 (41-43)	...	...	...	...	0.1	...	0.965	...	225 (437)	...
Poland	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Damas-Hamah . .	0.91-0.925	...	310 (590)	10 (50)	...	...	...	...	. .	...	0.87-0.93	...	260 (500)	...
Italy	...	...	290 (554)	15 (59)	...	...	...	5	...	...	...	...	...	...
French Nord . .	0.88-0.90	...	305 (669)	10 (50)	75-95	650-800	...	...	...	...	0.87-0.93	...	260 (500)	...
Jugoslavia . . .	...	...	310 (590)	...	...	...	...	5	...	...	...	0.890-0.945	260 (500)	...
Jugoslavia . . .	...	...	...	...	...	...	...	...	...	..	...	...	...	...
Czechoslovakia. .	0.92-0.95	...	310 (590)	...	...	...	...	4-6	0.1	...	0.95	...	250 (482)	...
Czechoslovakia .	...	...	. .	...	...	...	...	...	...	. .	...	...	...	...

aturated steam cylinders.						Oil for lubrication of motion parts.								
Viscosity				Asphalt.	Soap.	Density at		Flash point, Deg. C. (Deg. F.)	Freezing point, Deg. C. (Deg. F.)	Viscosity				Asphalt.
(Barbey)		(Engler)								(Barbey)		(Engler)		
at										at				
0° C. (12° F.)	200° C. (392° F.)	75° C. (167° F.)	100° C. (212° F.)			15° C. (59° F.)	20° C. (68° F.)			35° C. (95° F.)	100° C. (212° F.)	50° C. (122° F.)	100° C. (212° F.)	
324	...	...	...	0.34	3.38	0.935	...	158 (316)	-16 (3.2)	30	...	...	...	...
...	...	...	...	...	...	0.925	...	156 (313)	-12 (10.4)	30	...	...	...	0.54
...	...	...	...	...	...	0.927	...	172 (342)	- 6 (21.2)	35	...	...	...	0.26
40-220	800-1200	...	...	...	...	0.88-0.945	...	150 (302)	...	25-38	...	...	...	0.3
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	..	...	...	...	...	..	...	...	...	...	...
130	850	...	...	...	...	0.933	...	165 (329)	...	27	505	..	...	...
...	...	...	...	...	...	0.928	...	167 (333)	...	20	396	...	...	...
...	...	...	...	...	...	0.932	...	167 (333)	...	24	450	...	...	...
...	...	...	...	...	...	0.924	...	175 (347)	...	14	190	...	...	...
...	...	9	...	0.5	4.5-6	...	0.885	140 (284)	-15 (5)	...	...	8.5-10.5	1.9-2.5	...
...	...	...	3.5-7	0.2	...	...	0.940	180 (356)	-10 (14)	...	...	5.5-7	...	...
...	..	...	3	0.3	...	0 94	...	130 (262)	0 (32)	...	...	6	...	...
...	...	...	...	...	...	0.94	...	130 (262)	-22 (-7.6)	..	...	4.5	...	...
40-210	800-1200	...	...	...	...	0.900-0.945	...	150 (302)	-10 (14)	25-35	400-600	...	...	...
...	...	...	...	...	...	...	...	150 (302)	-10 (14)	...	...	9-12	1-5-2.5	...
40-220	...	...	...	...	...	0.900-0.945	...	150 (302)	-10 (14)	25-35	400-600	..	...	...
3.5-5	...	...	...	...	...	...	0.90-0.945	160 (320)	- 5 (21)	...	...	8-12.5	...	...
...	...	...	...	...	..	...	...	150 (302)	-15 (5)	...	...	6-8	...	...
...	...	...	3-5	0.2	...	0.96	...	130 (262)	0 (32)	...	..	6-7	...	...
...	...	...	...	...	...	...	...	...	-20 (-4)	...	...	5-6	...	...

TABLE B.

COUNTRY OR ADMINISTRATION.	Cylinders.	Axle boxes.	Rod bearings.	Tender axle boxes.
French Est	a) Mechanical lubricators. b) Sight feed lubricators.	In body with pin lubricators; lower bearing with oil pads or wool and horse hair.	a) Pin lubricators. b) Centrifugal lubricators.	...
P. L. M.	Sight feed lubricators.	Oil pads.	Capillarity lubricators.	...
French Nord . . .	Mechan. lubricators (Bourdon Télescopompe).	a) Oil pads; b) Mechan. lubricators	Pin lubricators.	...
Alsace-Lorraine . . .	a) Mechan. lubricators — Bourdon-Wakefield, Michalk, Dicker, Werneburg, De Limon. b) Sight feed lubricators.	Body with oil cups; lower bearing with oil pads and wool waste.	Pin lubricators.	...
French State	a) Sight feed lubricators. b) Mechanical lubricators.	The oil well is located in the top part of the box and is connected with the brass by oil holes in which wicks are engaged. Wool waste in lower box.	Pin lubricators.	a) From below with packing which is in contact with the journals. b) In the case of old tenders, with oil brushes.
Jugoslavia	a) Sight feed lubricators. b) Friedmann, Michalk.	...	...	...
Bulgaria	Friedmann mechanical lubricators.	...	...	...
Poland	a) Lubricators. b) Lubricating presses	Worsted cotton and lubricating press, Goldstein system.	...	...
Rumania	a) Nathan lubricators. b) Friedmann and Michalk lubricating presses.	...	...	...
Luxemburg	Friedmann lubricating presses.	Worsted cotton or oil pads or packing, pin lubrication.		...
Damas-Hamah . . .	a) Sight feed lubricators. b) Lubricating presses.	Oiling pads.	Worsted cotton with pin lubrication.	...
Italy	a) Sight feed lubricators. b) Friedmann or Michalk lubricating presses.	...	...	...
Czechoslovakia . . .	a) Friedmann or Michalk lubricating presses.	a) Oiling pads. b) Lubricating presses.	Worsted cotton with pin lubrication.	...

tainous country. From the point of view of repairs, the condition of the latter locomotives is the same as that of locomotives running on level lines. On the *French Est*, lubrication of the wheel flanges has not given good results. In *Italy* the lubrication of the rail heads on lines with small radius curves is preferred.

V. — Working.

The good condition of the locomotive as a whole and the resulting possibility of obtaining the maximum mileage between repairs including lifting, depend upon the regular attention given to the locomotive, which in turn depends upon the locomotive enginemen.

It is therefore essential to determine the best method of organising the service. When one set of men works the engine, which method naturally is likely to be the best in this connection, sufficient use is not made of the locomotive. On the other hand, when the engine is handled by more than two regular sets of men, the attention given to the engine is not usually satisfactory, and this reacts unfavourably on the general condition of the locomotive. In this case, it is generally not possible moreover to make proper use of the staff within the periods fixed by law. Table I hereafter shows the method of working locomotives on some railways. The letter *a*) denotes the usual method and the letter *b*) the exceptional method.

TABLE I.

COUNTRY OR ADMINISTRATION.	Single set of men.			Two sets of men.			Several sets of men.		
	Work done :								
	Passenger trains.	Goods trains.	Shunting.	Passenger trains.	Goods trains.	Shunting.	Passenger trains.	Goods trains.	Shunting.
French Est	*a*	*a*	*b*	*b*	*b*	*a*	...	...	*b*
P. L. M.	*a*	*a*	*a*	...	...	...	...	...	*b*
Paris-Orleans	*a*	*a*	*b*	*b*	*b*	*b*	...	...	*a*
French State	*a*	*a*	*b*	*b*	*b*	*b*	*b*	...	*a*
Alsace-Lorraine	*a*	*a*	...	*b*	*b*	*b*	*b*	...	*a*
Italy	*a*	...	...	*b*	*a*	*b*	...	...	*a*
Belgium	*b*	...	...	*a*	*b*	...	*b*	*b*	*a*
Bulgaria	*a*	*a*	*b*	...	*b*	...	*b*	...	*a*
Greece	*a*	*a*	*a*	...	...	...	...	...	...
Egypt	*a*	*b*	...	...	*a*	*b*	...	...	*a*
Poland	...	...	...	*a*	*a*	*b*	...	...	*a*
Rumania	*a*	*a*	*b*	*b*	*b*	*b*	...	...	*a*
Luxemburg	...	..	...	*b*	*b*	*b*	*a*	*a*	*a*
Czechoslovakia	...	...	*b*	*a*	*a*	*b*	...	...	*a*

This table shows that most of the railways employ a single set of men on engines working passenger and goods trains. Three sets of men are only employed in regular shunting service. The single set of men requires a relatively larger number of locomotives; on the other hand it must be admitted that locomotives are looked after more conscientiously by their own enginemen and as a result the total repair costs are reduced and the safety of the service is improved.

In its reply the *French Est* states that better results are obtained (particularly as regards the staff) by introducing long

distance turns than by increasing the number of sets of men. The same administration adds that the saving effected by a double manning is more than wiped out by the increase in the repair costs of the locomotives. The repair costs related to a single working hour are 1.50 fr. higher than with the double set of men than with the single set of men.

The *P. L. M.* remarks that
by multiple manning the number of locomotives required may be reduced, but this result is obtained at the expense of the maintenance, seeing that too little time is left for light repairs.

The *French State* states what follows :
In regard to maintenance we obtain with multiple manning the same results as with the single set system, but it is not certain whether favourable results would also be obtained with the multiple manning on the main lines.

In *Italy* and *Belgium*, the system of the double manning saves fuel and enables the number of locomotives to be reduced. *Bulgaria* has had bad results with the multiple manning from the point of view of the repair of the locomotives. *Rumania* estimates the saving in traction costs effected by double manning at 25 %.

The *Czechoslovakian State* Railways use double manning as much as possible in main line services and the results are satisfactory from the point of view of the rational utilisation of the locomotives and staff. No appreciable increase of the maintenance costs of locomotives is observed with this system. In order to use the locomotives in the most economical way, the turns of duty are got out for as long distances as possible, particularly when one set of men is used. It is true that the maximum continuous distance worked by a locomotive depends upon the way the railway is divided up, on the workings and in all cases on the supply of coal carried on the locomotive. As enginemen are rarely relieved during their turn of duty, the maximum mileage of a locomotive also depends upon the maximum mileage the enginemen make. The following table shows for some railways, the maximum continuous mileages of locomotives.

TABLE II.

COUNTRY OR ADMINISTRATION.	Maximum length of one continuous run. Km. (*Miles*).
French State	374 (*232*)
P.-L.-M.	250 (*155*)
Paris-Orleans	400 (*249*)
Alsace-Lorraine. . .	297 (*185*)
Bulgaria	150 (*93*) in mountainous districts, 250 (*155*) on favourable lines.
Rumania	310 (*193*)
Turkey.	340 (*211*)
Egypt	130 (*81*)
Poland.	377 (*234*)
Jugoslavia	250 (*155*)
Luxemburg.	300 to 350 (*186 to 217*)
Czechoslowakia . . .	Staff : 315 (*196*) ; Locomotives : 350 (*217*).

Generally speaking it may be said that on the Railways on which single manning is used, the maximum continuous run depends upon the maximum period of continuous duty allowed, this period being limited by the statutory provisions applicable in the country concerned. The eight-hour day may generally be taken as the basis with the breaks involved.

Thus for example, on the *Czechoslovakian State* Railways continuous duty on express trains is ordinarily limited to nine hours, the duty on passenger trains to eleven hours, the duty on goods trains to fourteen hours and duty on local lines to sixteen hours, including in each case one hour for preparing the engine and one hour for putting it away. The times

of duty also include stops not exceeding 2 hours in a terminus station, if followed immediately by working a train on the main lines.

On the *P. O.*, the day is made up of eight working hours, if no break is provided for meals and ten hours if the staff are allowed 30 minutes for meals.

In *Italy*, the working day for a single set of men is nine hours in passenger train working, ten hours in goods train working, including an hour for preparation and an hour for putting away. For multiple manning no limit is set and the day is fixed by taking proper consideration of the economical utilisation of the locomotive and the staff.

In *Bulgaria* the lists are so established that the staff return within twenty-four hours to their home station.

In *Rumania* a working day of nine hours is prescribed for passenger trains and of twelve hours for goods trains on the main lines.

In *Jugoslavia* the longest trip, at the present time about 250 km. (155 miles), is fixed by the distance separating the main depots, but it may be increased without difficulty to 350 km. (217 miles). When the line from Zagreb to Belgrade (425 km. = 264 miles) is completed, express trains will run over it without changing locomotives. The limit of the mileage worked by the men is undoubtedly fixed by the regulations governing the eight-hour day.

In order to obtain a continuous mileage as high as possible it is necessary to employ a high-quality fuel and, it may be, to use two firemen. On powerful locomotives, the dimensions of the grate correspond to this power without however exceeding the limit above which a fireman can no longer keep the grate covered nor continue to fire over the time required. Generally speaking it may be said that on the Railways with which the present report deals, the maximum continuous mileage of the locomotives does not depend upon the supply of coal carried on the tender, but on the maximum mileage the staff can work.

The *Czechoslovakian State* Railways have a number of locomotives with tenders on which the coal is brought forward mechanically (with manual operation) to the point at which the fireman picks it up with the shovel. The original Halla-Haken equipment has been reconstructed and tests made with the modified gear were satisfactory. The ash pans of the high-power locomotives are sufficiently large not to restrict the mileage the engine can run. If the coal consumption in one turn of duty exceeds 10 tons for single-expansion engines or 8 tons for three to four-cylinder engines, two firemen are employed. Table III shows the work demanded from the boilers in normal service .

The average mileage between two lifts varies for passenger locomotives between 70 000 and 110 000 km. (43 500 and 68 350 miles), and for goods locomotives between 45 000 and 94 000 km. (27 960 and 58 400 miles). The maximum mileage of passenger locomotives is about 137 000 km. (85 130 miles), and that of goods locomotives about 108 000 km. (67 110 miles). The following table IV gives detailed information on this subject.

To turn a locomotive on a turntable takes on an average 1 to 2 minutes with electric drive and 5 minutes by manual operation. 6 to 10 minutes are required to turn on a triangle. If the diameter of the turntable is too small and the tender has to be uncoupled, the time taken for turning is increased about 15 minutes. About 30 minutes must be allowed for the whole operation, i. e. uncoupling the locomotive from the train, turning the locomotive, cleaning the ash pan and smoke box, taking coal and water, backing the engine on to the train and testing the brake. This time depends upon the distance from the de-

TABLE III.

COUNTRY OR ADMINISTRATION.	Normal.	
	Coal consumption, kgr./m² (*lb. per sq. foot*) of grate area.	Evaporation, kgr./m² (*lb. per sq. foot*) of heating surface.
French State	250 (*51.2*)	35 (*7.17*)
Alsace-Lorraine	400—450 (*82—92.2*)	55—57 (*11.26—11.67*)
Italy	350 (*71.7*)	45-50 (*9.2—10.2*)
Belgium	200—350 (*41—71.7*)	25—45 (*5.1—9.2*)
Poland	260—350 (*53.3—71.7*)	40—60 (*8.2—12.3*)
Bulgaria	300 (*61.4*)	40 (*8.2*)
Rumania	300—400 (*61.4—82*)	20—60 (*4.1—12.3*)
Smyrna-Cassaba	327 (*67*)	34.7 (*7.1*)
Greece	350 (*71.7*)	50 (*10.2*)
Congo Colony	300—500 (*61.4—102*)	20-45 (*4.1—9.2*)
French Nord	400—700 (*82-143*)	28—50 (*5.7—10.2*)
Jugoslavia	350—450 (*71.7—92.2*)	40—50 (*8.2—10.2*)
French Est	292—378 (*59.8—77.4*)	43—55 (*8.8—11.3*)
Czechoslovakia	300—500 (*61.4—102*)	30—60 (*6.15—12.3*)

TABLE IV.

COUNTRIES OR ADMINISTRATION.	Average distance run.		Maximum distance run.	
	Passenger trains.	Goods trains.	Passenger trains.	Goods trains.
	Km. (*Miles*).	Km. (*Miles*).	Km. (*Miles*).	Km. (*Miles*).
French Est	68 502 (*42 556*)	54 392 (*33 798*)	98 500 (*61 206*)	65 500 (*40 700*)
Paris-Orleans	95 000 (*59 030*)	65 000 (*40 390*)	105 000 (*65 250*)	85 000 (*52 820*)
French State	75 000 (*46 600*)	55 000 (*34 180*)	85 000 (*52 820*)	65 000 (*40 390*)
Alsace-Lorraine	70 000 (*43 500*)	50 000 (*31 070*)	...	...
Italy	80 000 (*49 720*)	60 000 (*37 280*)	120 000 (*74 560*)	90 000 (*55 920*)
Bulgaria	110 000 (*68 350*)	90 000 (*35 920*)	120 000 (*74 560*)	100 000 (*62 140*)
Luxemburg	70 000 (*43 500*)	50 000 (*31 070*)	100 000 (*62 140*)	75 000 (*46 600*)
Jugoslavia	103 000 (*64 000*)	94 000 (*58 410*)	137 000 (*85 130*)	108 000 (*67 110*)
Congo Colony	...	45 000 (*27 960*)	...	...
Greece	100 000 (*62 140*)	...	120 000 (*74 560*)	140 000 (*86 990*)
North of Milan	100 000 (*62 140*)	...	125 330 (*77 880*)	...
French Nord	90 000 (*55 920*)	65 000 (*40 390*)	120 000 (*74 560*)	90 000 (*55 920*)
Czechoslovakia	90 000 (*55 920*)	66 000 (*41 010*)	130 000 (*80 780*)	100 000 (*62 140*)

pot to the station as well as the method of coaling the tender.

For cleaning the fires, when the coal is of poor quality, locomotives of recent construction are provided in some countries (for example *Bulgaria, Rumania, Greece, Jugoslavia,* as well as on the *French Nord* and the *Czechoslovakian State* Railways) with drop grates. Administrations who only employ high grade fuel have not of course fitted this arrangement.

* * *

The following means are resorted to in order to increase the daily mileage of the locomotives :

1. Use of double or even triple manning;
2. Long-distance runs without changing locomotives;
3. Special gangs used to prepare and stabling the engines (*French Nord*);
4. All the large depots have mechanical coaling plants;
5. The speed of goods trains has been accelerated (*Belgium*);
6. The establishment of the engine workings has been concentrated in a special office (*French Nord*).

Due to the adoption of the double manning, the *French State* has been able to reduce the number of locomotives in service by 15 %. The resulting saving in staff is estimated at 12 %. Similar results have been obtained on the *French Est.* Due to the introduction of long distance turns of duty, time on train working on the average by a set of men has been increased from 4 hours 52 minutes to 5 hours 59 minutes, without any change in the total continuous time on duty which averaged 7 hours 45 minutes. This represents a saving of 2 1/3 % or 33 sets of men.

* * *

The following Administrations have instituted premiums for high locomotive mileages :

	Premiums received by :
French Nord	Locomotive staff.
Paris-Orleans	Do.
Rumania	Do.
Egypt	Do.
Poland	Fitters and cleaners.
Smyrna-Cassaba	Locomotive driver.

The undermentioned Administrations grant a premium in the case of locomotives which are well maintained and which indirectly constitutes a premium for long mileage :

	Premiums received by :
Alsace-Lorraine	Locomotive staff.
Damas-Hamah	Do.
Belgium	Depot foreman, shop foremen, fitter-inspector, enginemen and firemen, firelighters and cleaners.
Paris-Orleans	Cleaners.

The cleaning of locomotives has an important bearing on safety because it facilitates the inspection of the mechanism and the detection of defects and damage. Moreover, the hygienic and psychological effects should not be lost sight of : actually, the enginemen very decidedly prefer to work on a clean

locomotive and endeavour to keep such an engine in a good condition of cleanliness. It would, however, be difficult to assert that a better cleaning would exert a definite influence on the mileage of locomotives. Nevertheless, cleanliness is essential for reasons of safety and good order.

VI. — General considerations.

The modifications and improvements made in the construction of locomotives have generally been of importance from the economical standpoint. They have mainly contributed to increase the radius of action of the locomotives for the same supplies of coal and water. Their effect has generally been to increase the output of the locomotives in ton-miles hauled. Finally repairs have been done more rapidly and at less cost.

According to the information received in the replies the particular modifications and improvements given below have favourably influenced the repairs which certain administrations make when the locomotives are lifted :

A. — *Boiler repairs.*

1. Manganese bronze staybolts at places which exhibit a tendency to develop cracks.
2. Welding of tubes to the firebox steel tube plate.
3. Use of electric welding for steel fire boxes.
4. Autogenous welding of cracks in copper fire boxes.
5. Use of feed water softening and purifying plants.
6. Increase in the radius of tube plate flanges.
7. Better positions for the washing-out holes.

B. — *Engine repairs.*

1. Use of cement-steel bushes and pins, particularly in the spring gear and the driving gear.
2. Bronze axle box liners.
3. Central lubrication.
4. Strengthening main frames, hornsheets and brasses.

The repairs have been speeded up by new methods of working which have been introduced by some Administrations and which consist essentially in entrusting each class of work to a special group of fitters, the operations being effected in accordance with a predetermined programme, the application of which is supervised by headquarters. The reducing of the time required for carrying out the repairs has been to increase the mileage in a given period.

* * *

In repairing bearings the work is carried out in the following sequence :

A. *Axle box brasses.* — The old white metal is melted out, in a melting furnace or by using an oxy-acetylene blowpipe (*Belgium*). The brass is cleaned by sandblasting, is examined and is checked for play in the box. A play of one millimetre (0.039 inch) is taken up when pressing the brass into the box; if the play is greater, liners are welded autogenously to the worn faces of the brass. If the journal collars are worn down considerably, they are built up by autogenous welding. The height of the added metal should be greater than the final dimensions so that the hard outer top layer can be removed by machining. Small incipient fractures of the brass are welded up autogenously and broken brasses renewed.

The repaired brasses are fitted into the boxes and are expanded by hammering to bed them rigidly in. The brasses are then heated and cleaned with a wire brush, after which they are trimmed in. They are then stood on end and white metal is poured in them. The brasses, introduced in the boxes, are then machined exactly to the diameter of the axle journals, either on a

boring machine or on a horizontal milling machine. Machining being completed, the brass is fitted to the axle journal, while still in the box. Red lead is used when bedding. With the exception of the Adams carrying wheels the brasses of which are fitted at the same time, each box is fitted separately. The boxes are provided on their lateral rubbing face with bronze liners which are renewed when necessary. The position of the centres of the boxes in the horns is checked by the use of the square and gauge.

B. *Connecting rod brasses.* — The connecting rod brasses, particularly those of express locomotives should be examined at other times in addition to the examination made when lifting the locomotive. The usual repair work is the following :

The white metal is melted out, the brasses are examined and any small cracks welded autogenously. Any slight side play is taken up by upsetting, a more considerable play by autogenous welding. If the distance between the two half brasses is excessive, the lateral faces are welded up autogenously. Afterwards white metal is poured into each half brass separately and the half brasses are fitted into the rods. After gauging the brasses inserted in the rods are bored out on special machines.

New brasses are only machined on the front faces where the two halves touch. The half brasses are tightened together by means of clamps and the whole brass is white metalled up. They are then machined on all faces to the dimensions of the rod. The brass lined with white metal is separated and each half is fitted, using red lead, into the rod. The centre is marked off and the machining of the front faces is shown so that after boring and machining the play has the prescribed value.

* * *

Slightly worn connecting and coupling rod pins are machined without unkeying. If the wear is rather considerable, machining is preceded by unkeying. If the pins are machined without removing them, this work is done by a special machine. The straight part (without the collar) is first scraped. Then the collars are tuned up by the removal of a thin shaving with a profiled cutter which is also employed to turn smooth the straight portion of the pin. After this, the whole surface is polished with emery cloth by a rapid forward movement. If the pins are removed before machining, this work is done on an ordinary boring lathe. After scraping the collars are turned smooth by means of a hand-fed profile milling tool. The surface is then filed and finally polished with a coarse and fine emery cloth. Hardened pins are ground after removal on a grinding machine. The surface of the pin (the collar being merely ground) is afterwards polished with emery cloth. The shape of the collard is checked up by means of a gauge each time a pair of wheels is repaired. Collars worn sharp are machined when the pins are done up. Crank axle crank pins are machined on special machines.

Summary.

The maximum mileage run by a locomotive between two repairs including lifting of the locomotive depends chiefly upon the wear of the tyres, which for reasons of safety should not exceed a predetermined limit. As long as the thickness of the tyres is sufficient, the wear of the flanges is the factor deciding the necessity for lifting the locomotive and re-turning the tyres. On some Railways, however, the express passenger locomotives are lifted every year, so that at the start of the heavy traffic period, the operating department will have at its disposal sufficient locomotives in good condition.

In order to reduce flange wear, the *Paris-Orleans* Railway has used high-tensile tyres and rails. Some administrations have introduced flange or rail lubrication for locomotives running in mountainous districts. No definite opinion can be given as to the utility of these methods at the present time. None of the Administrations to which the present report relates has carried out tests with a view to discovering a better tyre profile, although such tests would certainly be of importance.

Until a means for reducing tyre wear has been found, the bad state of the tyres will still be the chief reason for lifting the locomotive, lifting for any other reason being considered as exceptional. This remark applies in particular to the axle boxes, the repair and maintenance of which have to be given the greatest care if they are not to require attention before the normal period of lifting the locomotive. When lifting the locomotive, the pistons, valves, brasses, running gear and the boiler are also attended to. The extent of such repairs, and hence the time they require are very variable. The possible mileage in a given period depends upon these repairs which, in their turn depend upon the general condition of the locomotive and particularly of the boiler. In order to obviate extensive repairs to the boiler, certain measures have been taken which are dealt with in the chapter « General considerations ». In the same way, the time taken for repairs has been shortened on some Railways by reorganising the work and by controlling it and by standardisation of the parts. Nevertheless, the necessity for reducing the time taken up by the repairs still remains one of the most important questions of railway operation. The measures taken with a view to increasing the daily mileage of locomotives have been explained in the chapter « Working ». Of these measures, the double set of men has proved to be the most effective.

The periodical washing-out of the locomotive boiler should be based on the quality of the feed water. Each washing-out involves the stoppage of a locomotive for a certain length of time. It is therefore understandable that serious efforts are made to reduce this time as much as possible. This is the reason for the modern washing-out plants, as they make it possible to reduce the time of this operation by half and give considerable material economies by utilising the heat of the boiler water when the engine has worked its turn.

If a locomotive is to be utilised to the fullest extent, and consequently if its mileage is to be the maximum, necessary provisions must be made in the depots for the least possible time to be occupied in coaling, taking water and sand and in cleaning the ash pan and smoke box. Particular attention will be paid to ensure that the locomotive sheds are provided with modern coaling plants and modern arrangements for taking sand and water. The same applies to the handling of ashes. It is of course necessary for the financial factors to be taken into consideration, so that the said operations shall involve the least possible expenditure.

[625. 144.4. & 625. 17]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

12th SESSION (CAIRO, 1933).

QUESTION II :

The use of mechanical appliances in the permanent way maintenance and in track relaying.

REPORT No. 2

(Mexico, Central and South America; Belgium, Spain, France, Italy, Holland, Portugal and their Colonies; Denmark, Finland, Luxemburg, Norway, Sweden and Switzerland),

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Introduction.

First, we must express to the Congress our regret and disappointment in having to state that a large number of the Administrations consulted have either not replied or have not supplied the information requested for the purposes of this report. It follows that in view of the importance and size of several of these Administrations, our information will certainly be incomplete, but whilst sincerely regretting this fact, we are unable to remedy it.

Indeed, out of 156 Administrations consulted, only 65, i. e. 41.66 % have replied to our request.

Amongst these latter, 30 Administrations have submitted very interesting particulars, having already used and experimented with mechanical processes for the maintenance and renewal of permanent way; the other 35 who have replied have never carried out work employing such processes.

This means that only 19.23 % of the Administrations consulted have sent information which is useful for our report.

If a comparison is made as to the length of lines belonging to the Administrations consulted, one ascertains that, out of a total of 219 660 km. (136 490 miles), only companies owning 160 834 km. (99 940 miles) have replied, or 73.22 %, and amongst these the replies constituting a useful source of information that have been sent only represent 124 867 km. (77 590 miles), or 56.89 % of the total.

The table below gives in detail and according te Countries, the Administrations which have been grouped in conformity with the preceding principles.

The state of affairs indicated in this table is that existing at the time it was prepared; if further information is received it will be embodied in an appendix.

COUNTRY.	Administrations which have replied.				Administrations which have not replied.		Total.	
	With information.		Without information.					
	Number	Km.	Number	Km.	Number	Km.	Number	Km.
Argentine	4	18 652	2	6 570	3	9 392	9	34 614
Belgium	3	9 606	3	2 876	5	599	11	13 081
Brazil	...	...	...	...	5	11 565	5	11 565
Chile	...	...	1	664	2	1 570	3	2 234
Colombia	...	...	...	...	2	222	2	222
Denmark	1	2 602	...	...	4	626	5	3 228
Spain	2	9 411	4	273	5	2 304	11	11 988
Finland	1	5 009	...	...	...	...	1	5 009
France	10	46 023	11	11 026	18	11 039	39	68 088
Italy	1	16 850	...	...	21	4 132	22	20 982
Luxemburg	1	250	...	...	1	207	2	457
Mexico	...	...	...	...	1	12 005	1	12 005
Norway	...	...	1	3 467	...	...	1	3 467
Holland	2	3 636	2	5 212	2	557	6	9 405
Portugal	1	2 440	5	3 412	1	176	7	6 028
Salvador	...	...	...	...	1	161	1	161
Sweden	3	7 446	3	620	15	3 742	21	11 808
Switzerland	1	2 942	2	270	4	347	7	3 559
Uruguay	...	...	1	1 577	1	182	2	1 759
Totals	30	124 867	35	35 967	91	58 826	156	219 660

PART I.

Appliances used.

1. — *Does your Administration employ mechanical methods for the maintenance of its permanent way?*

2. — *Does it employ them for replacing or renewing certain sections of the permanent way?*

In both cases by mechanical methods are understood those which utilise a motive force, irrespective of its nature (electric, pneumatic, etc.) for driving the machine tools. Please indicate the nature of the motive force employed and the means of producing it.

In the affirmative, please state whether their use is effected normally and in a definite manner, either for maintenance or for renewal, or whether they are being employed by way of trial.

In the latter case, please state whether the trial is being conducted in a perma-

nent manner, as in ordinary maintenance, or whether it is an isolated trial applied in one or more isolated districts only.

3. — *For each case of application of mechanical methods, please give details on the machines and the methods employed, forwarding drawings and photographs and giving the price, make, makers or suppliers of the machines used and any other useful information.*

Please state also :

a) *whether wagons with special loading and unloading devices are used for the transport of ballast;*

b) *whether they are used for loading and unloading rails;*

c) *whether special machines are employed for screening the ballast;*

d) *whether small tractors hauling lorries are employed for the transport of materials;*

e) *whether the sleepers are unloaded mechanically in bulk or distributed along the section on which they are to be used;*

f) *whether the lower bottom layer of the ballast is rammed mechanically;*

g) *whether the sleepers are cut and drilled mechanically, and whether these operations are carried out on the spot where they are to be used or in the workshop before creosoting;*

h) *whether the sleepers are packed mechanically;*

i) *whether machines are used for tightening the coach screws. State whether this work is done in the shop — in cases where the design of the chairs employed renders this possible — or on the ground where they are be used;*

j) *whether the tightening of the fishplate bolts is done mechanically or by hand.*

In the latter case, are special spanners employed for carrying out the work quicker and easier ?

k) *whether the necessary cutting and drilling of the rails on the ground is done mechanically;*

l) *whether sections of track consisting of a couple of rails with chairs, sleepers, etc., are completely assembled and then transported to where they are to be used and laid;*

m) *whether weeding is done mechanically;*

n) *whether any other operation of maintaining or renewing the track is done mechanically. State which and the method employed.*

4. — *Has the adoption of the foregoing mechanical methods given rise to the work being done better, to a greater speed of working or to a saving in the cost of the operations ?*

5. — *In all cases, please state the approximate cost as compared with that of the same operation done by hand.*

Questions 1 and 2.

Argentine.

The four Companies which use mechanical appliances for the maintenance of the track are the *Buenos Ayres Great Southern* Railway, the *Buenos Ayres Western* Railway, the *Central Argentine* Railway and the *Cordoba Central* Railway. The only mechanical appliances used by the last named Company, are wagons with equipment for the discharging of ballast.

The other Companies carry out a variety of operations mechanically and in particular, packing. Althoug no longer in the experimental stage, this is not of general application, since the *Central Argentine* state that they only partially use mechanical methods, and the *Buenos Ayres Western* only apply them on local sections.

As regards renewals, this last Company states merely that it lays the track by pairs of pre-assembled rails.

The motive power used is compressed air obtained, in the case of the *Buenos Ayres Western,* by means of Ingersoll-Rand compressors, driven by petrol motors or by electricity in the electrified zones. Pneumatic power is obtained in like manner on the *Central Argentine* Railway.

Belgium.

For maintenance, the *Belgian National* Railway Company and, although on a smaller scale, the *Belgian National Light* Railway Company, make use of mechanical appliances.

For preference, the first of these Administrations uses them regularly for the renewal of the track and other plant along the line. They utilise electric power, but do not state its origin.

Denmark.

The *Danish State* Railways use experimentally and for maintenance only, a mechanical process for weeding.

In the renewal of certain sections of the track, they use mechanical plant for tightening coach screws and for packing sleepers.

The motive power employed is pneumatic (produced by Ingersoll-Rand compressors, the means of driving which is not indicated) electric or petrol.

The coach screwing machine is driven directly by a small petrol motor.

Spain.

None of the Companies which have replied, makes use of mechanical processes for maintenance purposes. The *North of Spain* Railway Company alone uses trollies in the electrified zones.

For renewals, this Company uses them solely for contract work on stretches of several kilometres; it uses machines for adzing and boring sleepers, machines for driving coach screws, and packing machines.

The motive power used is electricity, continuous current at 240 volts, obtained from generating sets driven by petrol motors.

These sets are of two types (figs. 1 and 2); the one of 15 H. P. fitted with wheels for travelling along the track, the other from 6 to 8 H. P. mounted on two wheels having pneumatic tyres.

The distribution of power over the work from the generator is effected by portable overhead leads of exposed twin copper wires or by flexible twin-core cable, plug points being provided at frequent intervals.

Finland.

The *Finnish State* Railways use mechanical appliances for maintenance only. They are using them experimentally for the packing of sleepers and as adopted practice for alignment, cleaning and weeding of the ballast.

In the first case compressed air is the motive power being produced by means of a petrol motor.

The machine for surfacing, cleaning and weeding the ballast is towed by a locomotive.

France.

From the replies received, it appears that, with a single exception, none of the *French Companies* use, as a matter of regular practice, any mechanical appliances for maintenance work and two only use them regularly for the renewal of the track.

Those which are using such appliances from the experimental point of view are the following :

The *Alsace and Lorraine* Railways state that trials are to be put in hand with a gang for renewing the track.

The *Paris Ceinture (Belt)* Railway uses, for maintenance and as an isolated experiment, pneumatic tools for driving coach screws and for packing sleepers, the compressor being driven by a petrol motor.

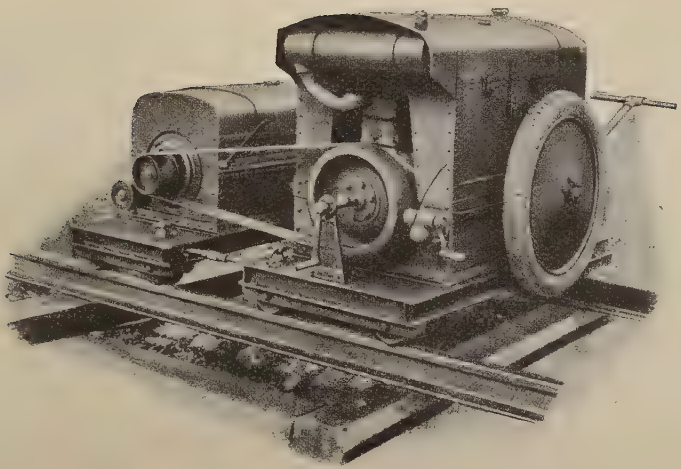

Fig. 1.

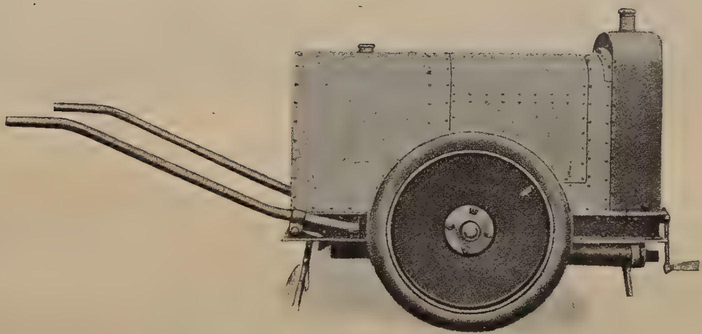

Fig. 2.

Midi Railway. — Trials in regard to maintenance were carried out from December 1924 to March 1927, on a section of the electrified line from Toulouse to Bayonne, but there has been no general application of mechanical methods. Use was made of the three-phase alternating current available from the traction supply, converted from 10 000 to 220 volts by a transformer of 10 *kva.* Its radius of action was 500 m. (1 640 feet) from the transformer.

The transformer is mounted on a trolley (fig. 3) and can be coupled to the live rail at certain places where suitable plug points have been fitted.

No mechanical appliances have been employed for the renewal of the track.

Nord Railway Company. — This is the only Company amongst those replying which definitely adopts mechanical processes for track maintenance. These processes comprise the tightening up of

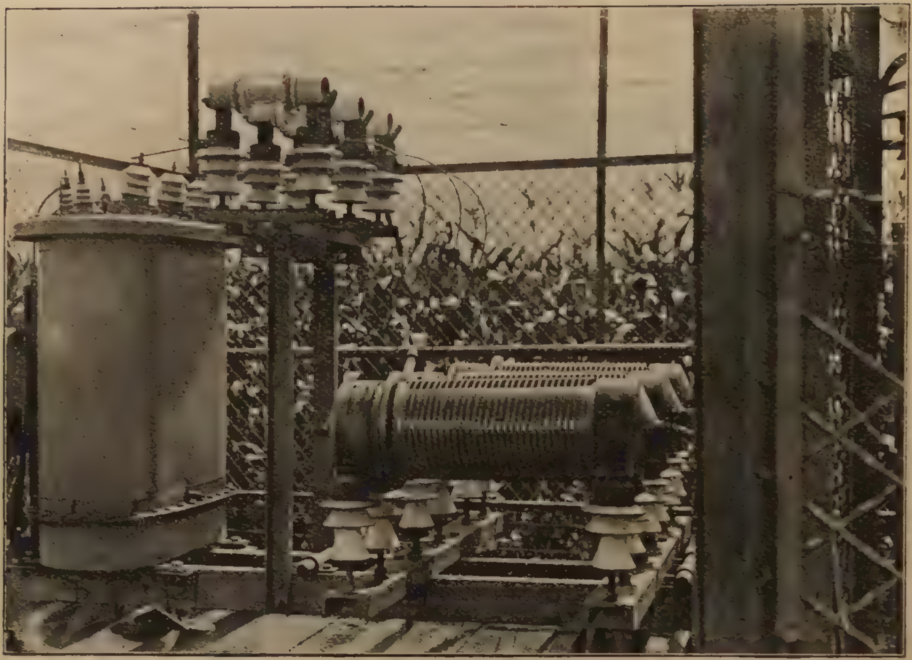

Fig. 3.

the coach screws and the packing of the sleepers, although for the latter work shovel packing is still in use. The first trial took place in 1931.

As regards renewal of the track, mechanical processes are used for the following operations : opening up the road and screening the ballast, unloading of rails 24 m. (78 ft. 9 in.) long and the setting in position of pairs of rails preassembled on sleepers; moreover, mechanical means are used for tightening coach screws in the workshops where the sections of track are assembled, and the packing of the track once it is in position.

For tightening the coach screws and for packing, Collet tools are used and they are driven by petrol generating sets manufactured by the same firm.

The operations of opening up the road and screening the ballast are performed by Drouard and Scheuchzer machines, the former being driven by electricity (current being generated by a steam or petrol set mounted on a wagon) and the second by an internal combustion engine mounted on the screening plant itself.

Paris-Orleans. — Have quite recently made experiments as regards maintenance, particularly with respect to packing and driving coach screws. They let renewal work out on contract and use a certain number of machines for packing, driving coach screws and adzing sleepers.

The motive power is compressed air for the Krupp packers and electricity for the other machines of the Collet type. (No details are given as to the source of the power).

Paris - Lyons - Mediterranean. — For maintenance they use tamping machines and coach screw driving machines. Although the trial period is over, their use has not been generalised.

Renewal work is entrusted to contractors who have liberty to make their own choice between mechanical and manual methods.

Petrol generating sets supply the necessary current and in addition two sets of pneumatic tampers used are also driven by petrol motors.

Algerian State Railways. — Have started trials in the renewal of a section of the line by contract.

The « *Bouches du Rhône* » *Railways and Electric Tramways* have used a weeding machine only.

The Companies making the use of mechanical appliances a part of their regular practice are the following :

French State Railways. — Several years ago this System made experiments in maintenance which, however, were not followed up; on the other hand, in renewal work they regularly employ mechanical methods.

Electric power is used in connection with the Collet machines, except for ballast screening, for which Scheuchzer machines are utilised, driven by petrol engines.

The *Est Railway* has made use of mechanical methods for the last two years. The power is electricity for the Collet machines or petrol motors for the tractors and trollies and Scheuchzer machines for ballast screening.

Italy.

The *Italian State* Railways make use of mechanical appliances only for the permanent way maintenance.

These appliances are on trial on a single track section 352 km. (219 miles) long and 230 km. (143 miles) of double track lines.

Power is supplied by petrol driven Ingersoll-Rand air-compressors. Compressed-air tools are used for driving and untightening coach screws and for tamping the ballast.

The following mechanical appliances are also in use :

— Small tractors for hauling trollies.

— Adzing and boring sleepers before treatment and also out on the track during maintenance work.

— Cutting and drilling rails.

— Mechanical weeding (Scheuchzer machine).

Luxemburg.

The *Prince Henry Railway and Mining* Company only performs the mechanically adzing of sleepers, and chemical weed-killing is done by means of portable projectors.

Holland.

The *Netherlands* Railways carry out mechanically such processes as packing, coach screwing, adzing of sleepers and weeding, but not as a matter of general routine. They do not use any mechanical process for the renewal of the track.

Portugal.

The *Portuguese* Railways intimate that they intend to make trials in mechanical maintenance, but at present all that is done by this means is the adzing of sleepers. They do not employ mechanical appliances in carrying out renewals.

Sweden.

The *Swedish State* Railways and the *Uppsala Norrland* Railway, use mechanical methods for several operations that might be termed auxiliary to maintenance, such as special ballast wagons, cranes for unloading rails and small power trollies. As regards permanent way maintenance work, only weeding is carried out mechanically.

The application is even more limited on the *Gränsgesberg-Oxelösund* Railway which uses only special wagons for ballast and chemical weeding.

Switzerland.

The *Swiss Federal* Railways use a number of machines for maintenance although these do not constitute a mechanical maintenance organisation.

They use special wagons for ballast and for unloading rails, machines for adzing sleepers, screening ballast, rollers for consolidating the formation and the lower layer of ballast, Krupp packers, coach screw drivers, chemical weeders, trollies and tractors for the transport of materials.

The renewal of the permanent way is carried out by contract with mechanical appliances belonging to the contractor.

Question 3.

a) *Transport of ballast.*

The use of special wagons for the transport of ballast is widespread.

Three of the four Argentine Administrations which adopt mechanical processes make use of them. The *Buenos Ayres Great Southern* Railway and the *Buenos Ayres Western* Railway use hopper wagons, and the *Cordoba Central* Railway uses wagons with special equipment for unloading, but no details of these have been supplied.

They are also used — but no particulars as to type are given — by the *Danish State* and the *Finnish State* Railways.

They are regularly used in *France* by the principal Companies with the exception of the *Midi*. The *State* Railways possess 600 hopper wagons. The *Est* Railway uses wagons similar to those of the ordinary medium-depth type, but with a hopper opening along the lower part of the side. The *Nord* Railway uses special wagons of the high-sided type but having low hoppers in the sides between the two wheels and operated by a lever from a platform situated at the end of the wagon . In this manner the ballast is shot out on to the side of the track.

The *Paris-Lyons-Mediterranean* uses hopper wagons of a special type with four axles, two at the centre and one at each end (figs. 4, 5 and 6). The *Swedish State* Railways and the Railway from *Uppsala-Norrland* Railway also use hopper wagons which discharge from the underside, with or without bogies (fig. 7), and the *Grängesberg Oxelösund* Railway uses wagons with hinged sides.

Finally the *Swiss Federal* Railways use wagons of the « Ochsner » system with a capacity of from 15 to 20 tons. They have low sides and the bottom is pivoted about the longitudinal axis of the wagon. The side toward which the bottom tilts remains stationary and the ballast is projected from the underside of the wagon. The opposite side follows the bottom in its movement (figs. 8 and 9). The cost of these wagons is from 13 500 to 15 000 Swiss francs.

b) *Loading and unloading of rails.*

For this operation, the reply of the majority of the Companies has been in the negative and the devices used are worked by hand.

The following Companies are the only ones which have either tried or adopted mechanical unloading of rails.

The *North of Spain* Railways have tried 2 types of devices which are hand operated. The one type consisted of fixed frames situated at the ends of the wagon and on which lifting tackle travelled on a runway; the other consisted of detachable brackets of the « Heckel » type. Neither of these gave satisfactory results.

The *French Est* Railway uses bogie wagons fitted with special frames carrying a hand winch.

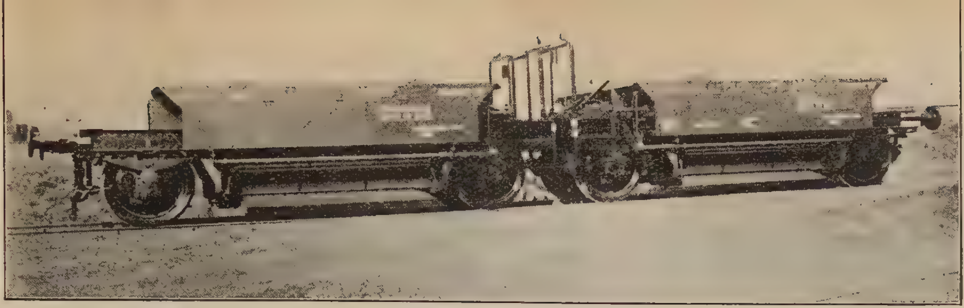

Fig. 4.

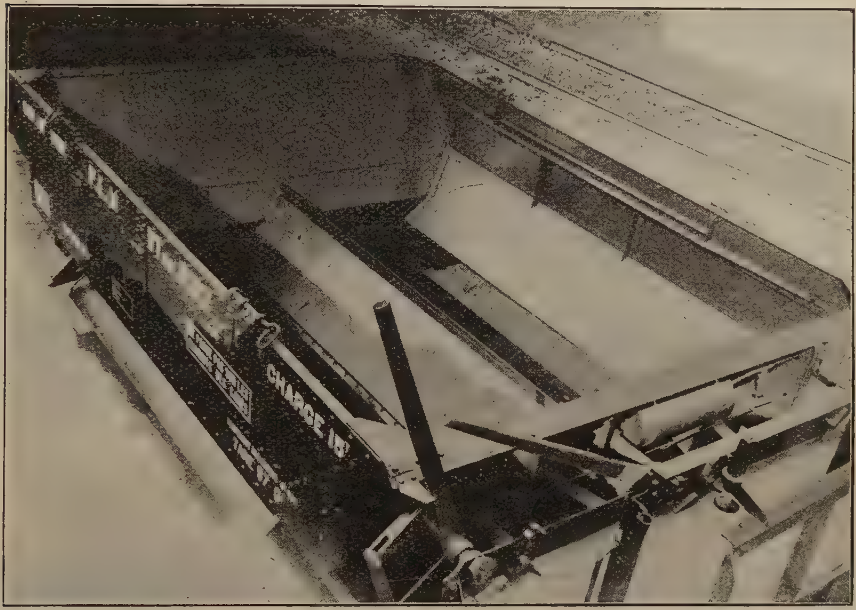

Fig. 5.

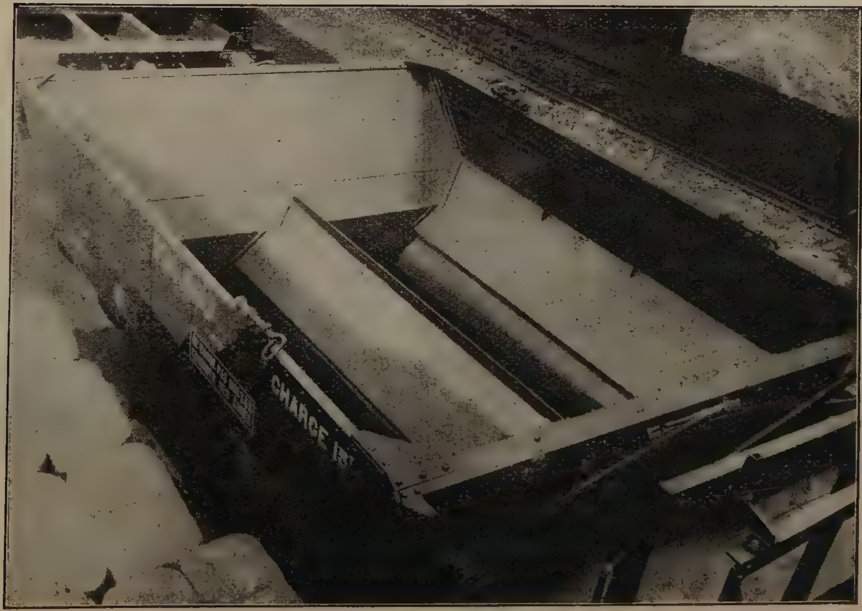

Fig. 6.

Fig. 7.

The *French Nord* Railway uses different devices for rails of 18 m. (59 ft. 5/8 in.) and 24 m. (78 ft. 9 in.).

The 18-m. rails are carried on the usual type of flat bogie wagons, provided with two overhead frames and tackle for unloading (fig. 10).

For the transport of the 24-m. rails weighing 46 kg. per m. (92.7 lb. per yard) (figs. 11 and 12), special wagons have been constructed consisting of a beam in the form of an inverted T, which bears, through the medium of pivots, on two bogies spaced at 30 m. (98 ft. 5 in.) centres. The rails rest on the horizontal sides of the T. Each wagon carries 24 rails 24 m. long. For the purpose of unloading them there are devices fixed on the upper part of the T. These are worked electrically and take current from a petrol generating set carried on a wagon forming part of the train.

Netherlands Railways : Reference should be made to the report of Mr. Chas. Driessen, Chief divisional officer of the Way and Works Department of these Railways, which was presented at the Madrid (11th) Session, 1930. (*Bulletin of the Railway Congress*, February 1930.) According to this report, the mechanical processes introduced had not given satisfactory results and had been abandoned. The method followed consisted essentially of securing the rail, which had to be discharged on to the track, at its rear end and slowly advancing the wagon.

The *Swedish State* Railways and the *Uppsala-Norrland* Railway, use simple cranes mounted on flat wagons.

The *Swiss Federal* Railways use, experimentally, appliances of the systems « Robel » (Munich, Germany) and « Niemag » (Niederrheinische Maschinenfabrik G. M. b. H., Duisburg Meiderich, Germany). Both of these, when in use, are mounted on wagons. The « Robel » system comprises two cranes with luffing jibs, one at each end of the wagon

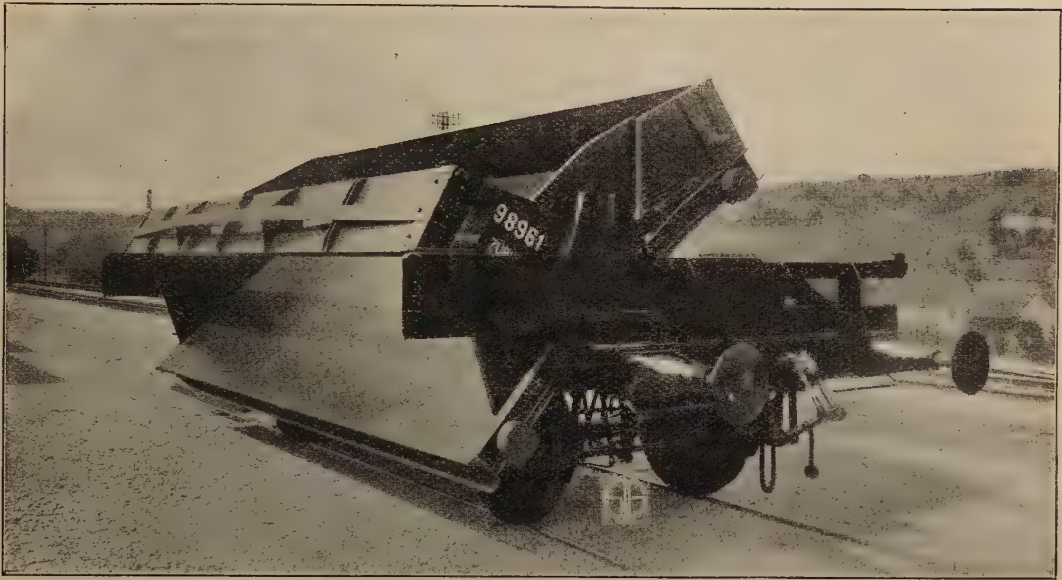

Fig. 8.

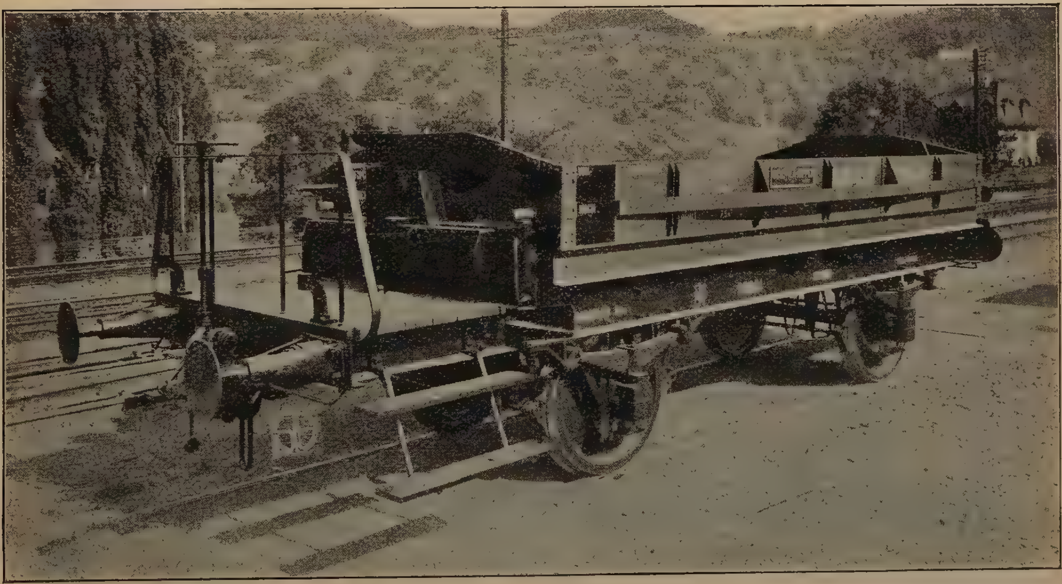

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

(fig. 13). The « Niemag » consists of two cantilever frames, one at each end of the wagon.

c) *Screening of the ballast.*

The four Companies making use of mechanical processes for this purpose are the following :

French State Railways. — Carry out this work only on contract, with machines for opening up the road and screening machines of the « Scheuchzer » and « Drouard » types.

French Est Railway. — In its organisation for mechanical renewals this Company also uses machines for opening up the road and « Scheuchzer » and « Drouard » screeners (figs. 14, 15, 16 and 17).

French Nord Railway. — Uses mechanical screeners of the « Scheuchzer » and « Drouard » types for renewals.

Electrical energy produced by a steam-driven set of 150 H. P. is used.

The train for the screening work, as employed by the *Nord* Company, consists of four units : the screener, behind which comes the wagon with the steam-driven generator, followed in its turn by a tank wagon. On the other side of the screener is another generator wagon, but petrol driven, as a reserve.

Whilst working, its rate of travelling is 150 m. (492 feet) an hour and it may reach 180 m. (590 feet).

The screener proper (figs. 18, 19, 20 and 21) comprises a chain of buckets which scrape out the ballast over a width of half the formation and empty it on to endless belts which lift it to the screening cylinder, whence another endless belt returns the screened ballast to the road, whilst a third belt throws out the rubbish laterally.

In order to avoid returning the rubbish to the road, whence it would be necessary to remove it by hand, recently special wagons, have been brought into use for the reception of the rubbish. Such a wagon comprises two hoppers; one

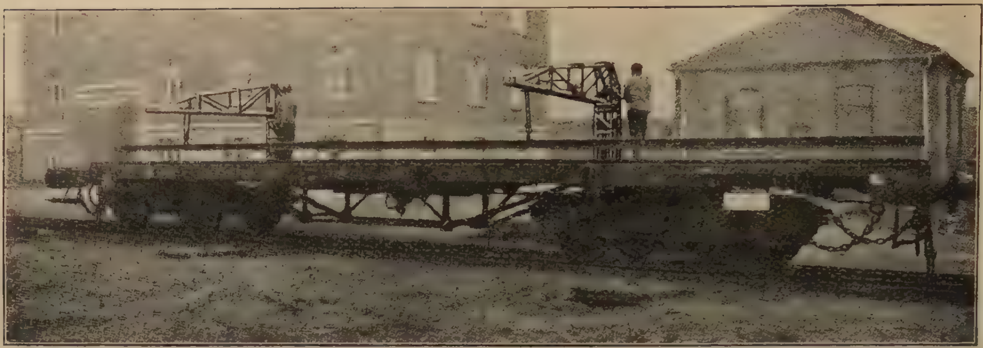

Fig. 13.

fixed, which receives the rubbish from the excavated material, and the other self-propelled by means of a petrol motor and capable of passing under the fixed hopper to receive its contents and tip them into one of the attendant wagons. To do this it travels on rails fixed above the level of the sides of the wagons.

Swiss Federal Railways. — A Scheuchzer machine is used for screening the ballast. The work is done by contract.

* * *

As may be seen, the work is performed almost exclusively with the « Scheuchzer », combined ballast remover and screener employed by the three Companies which do this work mechanically, although the ***French State*** Railways also make use of Drouard machines.

The Scheuchzer ballast remover and screener is made by the « Société Anonyme Scheuchzer » of Renens (Switzerland) (fig. 14) which contracts for this work on several European systems, as we have already seen.

This machine first uncovers the track by removing all the ballast including the lower layer situated under the sleepers.

After being deposited on one side of the track, the ballast is hoisted by a chain of buckets to a rotating screen which separates the small. The latter is thrown into a heap by the side of the track whilst the stone constituent of the ballast, which is now cleaned, is once more returned to and spread evenly over the track.

This machine functions by advancing along the road where it screens the ballast, without the necessity of dismantling a single part. It is sufficient if it is supported on wood blocks during the time between the opening up of the permanent way and its re-bedding with the clean ballast.

The rate of progress is from 130 to 140 m. (425 to 460 feet) an hour and 175 m. (575 feet) may be attained on favourable sites.

It is driven by a heavy oil engine of 100 H. P. which is also capable of driving the machine from one place to another at a speed reaching 50 km. (31 miles) an hour; its weight is 22 tons.

This machine may be removed from the track at any point. For this purpose it has transverse wheels which permit of it travelling in a direction at right angles to the track on which it is working, on rails placed for this purpose, thereby enabling traffic to pass and avoiding shunting work.

Fig. 14.

Fig. 15.

Figs. 14 and 15. — « Scheuchzer » ballast cleaning machine.

Fig. 16. — « Scheuchzer » ballast cleaning machine.

Fig. 17. — « Drouard » ballast cleaning machine.

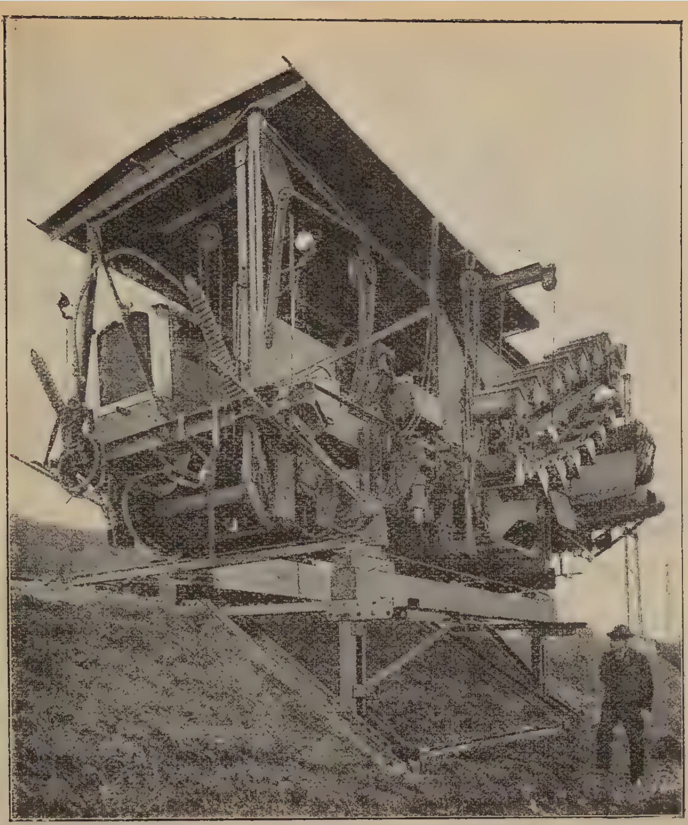

Fig. 18.

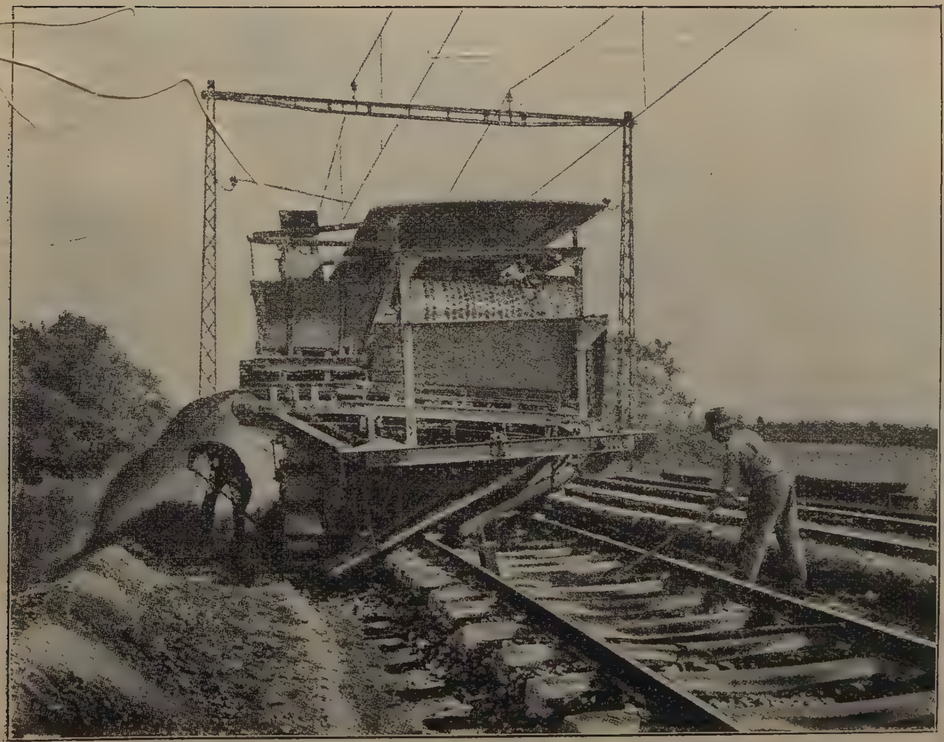

Fig. 19.

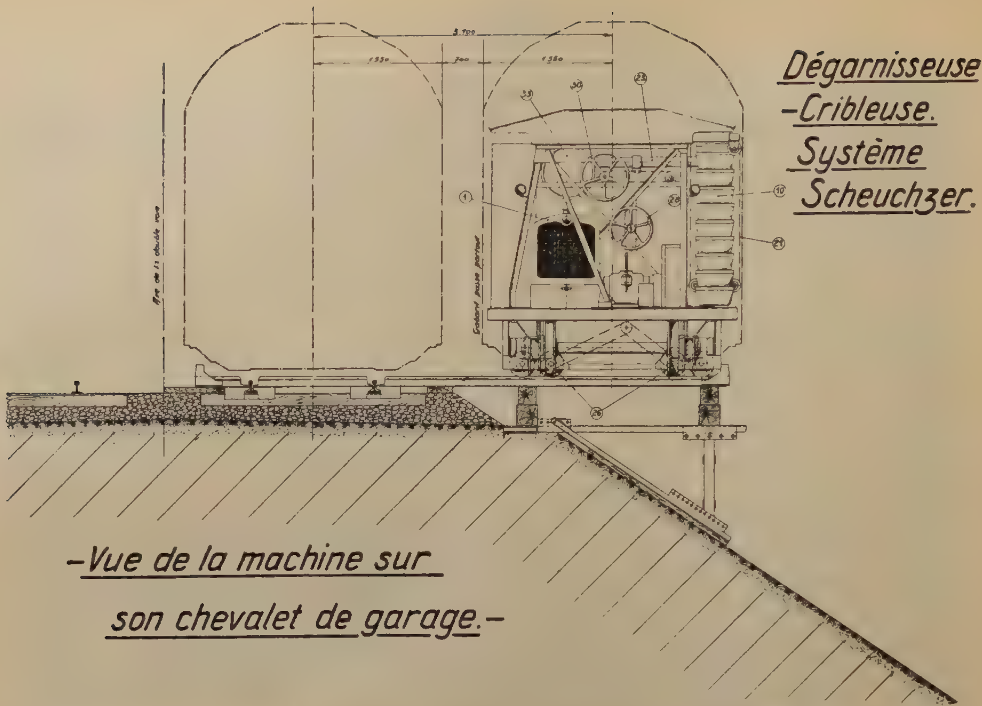

Fig. 20. — « Scheuchzer » ballast cleaner, clear of the track.

Fig. 21.

The Drouard screener operates in a manner similar to a bucket excavator. The road to be renewed must be completely taken up and the machine occupies an adjacent track. It cannot, therefore, be used on a single line and, during its operation, it blocks a double line.

d) *Tractors and trollies.*

Although they have a diversity of uses, tractors and trollies are regularly used by many Companies.

The *French Est* Company, in its mechanical renewals, uses locomotives for the transport of the pre-assembled sections of track.

So far as the haulage of trucks for the conveyance of materials is concerned, the *Belgian National* Railways use one tractor, in conjunction with each relaying gang, for the distribution of material.

The *French State* Railways use motor trollies of 40 H. P. capable of hauling up to 20 tons.

The *French Est* Railway, for maintenance work, uses motor trollies of 15, 20 and 40 H. P.

The *Paris-Lyons-Mediterranean* Railway uses trollies of 30 to 40 H. P. which convey not only rails, sleepers and small material, but also ballast in trucks designed for the purpose.

The *French Nord* Company uses a great variety of motor trollies manufactured by the firms of Compagne and Renault, which we can place in two types according to their power and their application : Trollies of 15 to 20 H. P. (fig. 22), which can pull one or two trailer trucks (up to 6 tons) and which are used for day-to-day maintenance. Trollies of 40 H. P. (figs. 23 and 24) can pull (up to 14 tons) a couple of trucks for the transport of sections of assembled permanent way. They are, therefore, applicable not only for current maintenance, but also for the renewal of the track.

Special trailer units are used with each variety of tractor trolley. Those used with the first type have a useful capacity of 1 800 kgr. (1.77 Engl. tons) and the others one of 7 000 kgr. (6.9 Engl. tons).

The *Swiss Federal* Railways use tractors of 35 to 40 H. P. (makers, Aebi of Zurich) which can haul trollies trucks and even ballast wagons. Their cost is 13 000 Swiss francs.

The *North of Spain* Railway Company uses petrol motor trollies of 24 H. P. (makers, Compagne), with room for 12 passengers, and 50 kgr. (1 100 lb.) dead load. They are employed on the electrified zones for hauling small wagons with scaffolding for the repair of the overhead lines.

This Company also uses a small twin-cylinder motor tractor of 15 H. P. for effecting repairs to the colour light signals of the section between Madrid and Villalba (38 km. = 23.6 miles).

Although providing no indication of either their capacity or function, the *Buenos Ayres Western, Danish State, Paris-Ceinture, Midi, Paris-Orleans, Swedish State* and *Uppsala-Norrland* Railways likewise employ motor trollies or tractors.

Those used by the *Swedish State* and the *Uppsala-Norrland* Railways are of small capacity with twin-cylinder motors manufactured by Berg & Co. Mek, Verstad, Ullerzater, Sweden, and their cost is 1 085 Swedish crowns.

e) *Unloading of sleepers.*

Amongst all the replies received, only the *Buenos Ayres Western* Railway Co. state that they make use of cranes for the unloading of sleepers which, depending on the nature of the work, is also done by hand.

The other Administrations do this

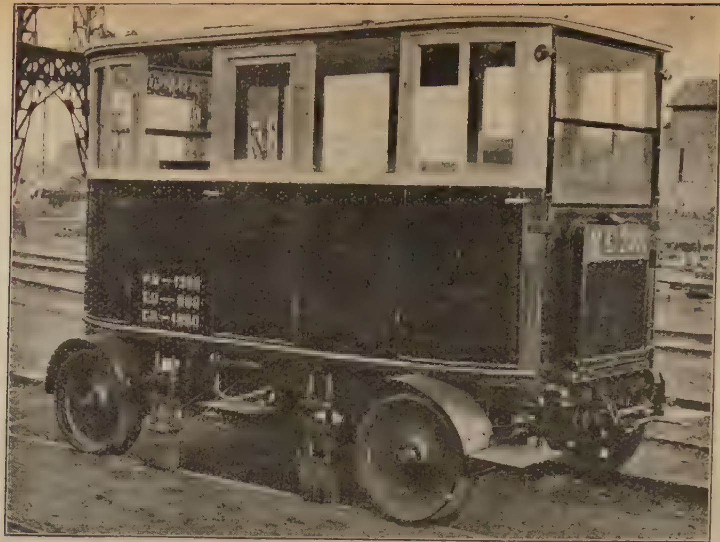

Fig. 22.

Fig. 23.

Fig. 24.

work exclusively by hand, either by distributing directly when unloading the wagon, or by unloading at a station and transporting to the point where they are to be used, on trucks or trollies, but without mechanical assistance.

f) *Consolidation of the lower layer of ballast.*

It may be said that the *Swiss Federal* Railways alone have mechanical means for the consolidation of the lower layer of ballast.

They use compressor cylinders of 4 to 6 tons and state that the contractors have to supply these compressor cylinders and it is, therefore, to be assumed that this work is performed by contract. The cost of a compressor cylinder is 1 000 Swiss francs.

Amongst the other Administrations only the *Danish State* Railways state that they are experimenting in consolidation but no particulars of the method employed are given.

g) *Adzing and boring of sleepers.*

This operation is performed mechanically by the majority of Companies.

We can draw up the following analysis, according to the methods of carrying out the work :

1. Companies who perform this operation in the workshops for the preparation of sleepers, before they are impregnated.

These are the following : *Belgian* Railways, with Collet plant; *Danish State, French State, Paris Ceinture, French Est, French Nord* and *Italian State.* The *French Nord* sends the sleepers withdrawn from the road but still serviceable, to the shops where new ones are treated, for the purpose of being adzed and bored afresh if this is practicable.

The *Paris-Orleans, Paris-Lyons-Mediterranean, Algerian State, Prince Henry* (Luxemburg), *Netherlands* Railways, *Portuguese* Railways and the *Swiss Federal* Railways propose to experiment with a machine which will adze and re-bore sleepers without removing them from the road, thereby making possible the substitution of one type of rail for another, without having to replace the sleepers.

2. Administrations adzing and boring sleepers at points close to the work.

These are the *Buenos Ayres Southern* Railway and the *Buenos Ayres Western* for permanent way on new lines and the relaying of the track (ordinary maintenance work is done by hand). The North of Spain Railway makes use of Collet electrically driven machines fed by an 8-kw. generator for renewal works.

The *Midi* Railway adzes and bores sleepers where the work is to be carried out but does not say if this is done mechanically. The *Finnish State* Railways and the *Gränsgesberg-Oxelösund* Railway state that on account of their particular type of permanent way, they do not adze the sleepers.

The *French Est* collects sleepers withdrawn from the road, at certain fixed locations where they are sorted; those found serviceable are adzed again and re-bored and the old holes plugged up. The work is carried out by contract with a Collet machine.

The *North of Spain* Railway adopts a similar procedure, but only when the track is being relaid by mechanical means. The sleepers of a track to be taken up are all removed, sorted and adzed afresh, re-bored and old holes plugged, if they are serviceable; then they are replaced in the new track but interposed with other new sleepers.

h) *Mechanical packing.*

This is an operation generally performed by mechanical means. It is used by the following Administrations :

Argentine.

The *Buenos Ayres Western* definitely uses it. It possesses two gangs with Ingersoll-Rand type 20 machines, the one driven by a « Wankesha » petrol engine of 26 H. P., and the other by an electric motor of 15 H. P. Each actuates eight tampers.

The *Central Argentine* undertakes mechanical packing on a very small scale and also uses pneumatic apparatus, the compressors being worked by electricity.

Europe.

The *Belgian National* Railways have a small number of plants of the Collet type.

The *Danish State* Railways undertake mechanical packing as regular practice in the relaying of permanent way. No details are supplied as to the plant used.

The *North of Spain* Railways make use of this procedure in renewals but not as a matter of regular practice. In certain cases, although mechanical methods are in use, the packing is done by hand, in the event, for instance, of the ballast bed being thin. Collet appliances with eight tampers are employed.

The *Finnish State* Railways make tentative use of pneumatic packers of German and Swedish types. Their cost is from 30 000 to 40 000 Finnish marks.

The *French* Administrations generally use mechanical packing.

The *State* Railways employ this procedure for certain renewal works and use the Collet machines with eight tampers. This Company has made trials in regard to maintenance, but since 1930, it has replaced mechanical packing by ordinary shovel packing, thereby obtaining greater output with less fatigue to the men.

Paris Ceinture Railway. — Its maintenance gangs are making experimental use of mechanical packers, whose compressor is driven by a petrol motor.

The *Est* Railway employs Collet machines in its organisation for mechanical renewals.

The *Midi* Railway has used, as an experiment in maintenance, from 1924 to 1927, on an electrified section of the Toulouse-Bayonne line, some Collet packers having four tampers (fig. 25). This trial has not been extended generally and it has not been applied to renewal work.

The *Nord* Railway uses Collet packers with four coupled tampers, which enable the sleeper to be packed simultaneously at its ends from both sides of the rail.

Electrical energy is furnished by a generating set which also supplies the coach screwing machines.

These packers are used for both renewal and maintenance work, although for the latter the « measured » shovel packing is also utilised, which does not require any mechanical plant and which gives results equivalent to two mechanical packers with a smaller number of workmen and with less strain upon them.

The *Paris-Orleans* Railway has recently used, for renewals, two types of Krupp packing machines with two tampers, and the Collet type with four and eight tampers. The cost of the first is 27 000 francs, and that of the second ones is 54 000 francs. These packing machines are made use of for renewals by several contractors.

The *Paris-Lyons-Mediterranean* uses them for maintenance, driving them from generator sets. In addition, they have two groups of packing machines driven by compressed air. For renewals the contractors have every liberty in the choice of methods to be used.

The *Swiss Federal* Railways are employing experimentally twenty packers of the Krupp, A.-G., Essen, Germany.

The *Netherlands* Railways have made trials with pneumatic packers, each pair of rammers being driven by means of a small petrol motor with a compressor. The result obtained has been satisfactory, so far as output is concerned, but not when the upkeep of the plant is considered, as this has been found to be fragile and to necessitate frequent stoppage of the work. The cost of a machine with two tampers is 1 800 florins.

Finally, the *Algerian State* Railways are beginning to use packing machines in renewal work. As their adoption is of such recent date, they are unable to give any idea of the value of these machines.

i) Mechanical driving in of the coach screws.

This is also one of the operations for which mechanical processes are the most widely adopted, particularly as regards renewal work.

We will point out that the use of coach screws is almost universal, for the *Buenos Ayres Great Southern* Railway alone makes use of spikes.

The Companies using mechanical methods for this kind of work in renewals are :

The *Belgian National* Railways. — Use Collet machines to a certain extent and perform the work on the spot. The fixing of plates for curves of smaller radius than 600 m. (30 chains) is done at the shops.

Danish State Railways. — Use machines supplied by the Danish firm Oleuse and Christensen, Charlottenlund, driven directly by a small petrol motor mounted on the frame of the machine itself.

North of Spain Railways. — Use Collet monorail machines for renewals carried out by contract. Two are attached to each job and also serve to extract the coach screws from the old road.

French State Railways. — Use Collet machines for the relaying of the road with flat-bottomed rails. Their use for maintenance has not been made general.

Est Railway. — Uses them in their organisation for mechanical renewals by assembling the permanent way by pairs of rails in the workshops. Collet machines are likewise used.

Mechanical methods are used for ordinary maintenance by the following :

Paris Ceinture Railway. — Employs pneumatic coach screwing machines driven by a petrol motor in its mechanical maintenance gangs which are organised for experimental work.

Midi Railway. — In its recently conducted trials in mechanical maintenance has used these processes by employing the Collet monorail machines (fig. 26), but they have not been put into general use.

Nord Railway. — Carries out mechanical tightening of coach screws by the mechanical maintenance gangs and in the assembling shops where the sections of track for renewals are prepared.

For this work Collet coach screwing machines are used as also for tightening the bolts securing the rails to metal sleepers.

In addition to this machine driven electrically, they use the « Lompret-Juillet » type, operated manually, which accelerates the tightening and loosening of the coach screws by making the work less arduous. This machine consists essentially of an ordinary coach screw spanner actuated by a hand wheel, which can equally well be a ratchet and lever, in order to produce a greater effort during the last stage in the tightening of the coach screw.

The action of this machine being reversible, it serves for loosening the coach screws; the lever mechanism is then used at the start of the turning and the hand wheel completes the removal.

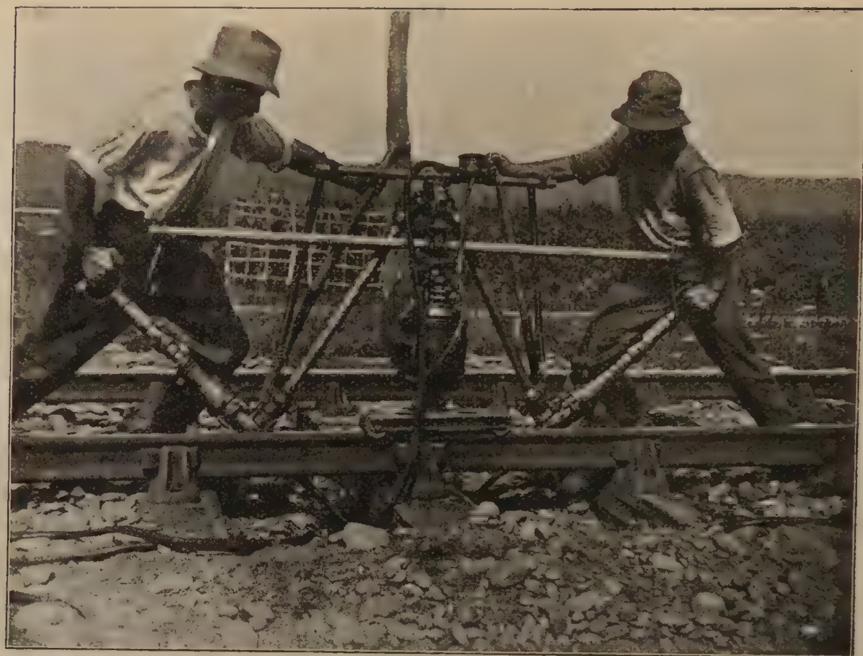
Fig. 25. — Midi Railway. — Collet tamping machine.


Fig. 26. — Midi Railway. — Collet coach screw driving machine.

Paris-Orleans. — Uses Collet coach screwing machines experimentally and recently. — Their price is 37 290 francs per outfit, including generating set and three coach screw driving machines.

Paris-Lyons-Mediterranean. — Although the trial is completed, the Company has not generally adopted these machines, but does not supply details as to the reason for this nor of the types of machine employed.

The *Netherlands* Railways and the *Swiss Federal* Railways state that they perform mechanically the tightening of coach screws in the workshops. Since later on they indicate that the assembling of the track is performed on the site of the renewal, this work cannot be of great importance, especially where Vignole rails are concerned.

j) *Tightening of the fish plate bolts.*

This operation is carried out by hand by all the Companies who have sent replies; they use a variety of special spanners; the « Robel » type on the *Madrid-Saragossa-Alicante* Railway and on the *Swiss Federal* Railways. These are the only Companies which specify the type of spanner in use. The following Companies have special spanners in use but give no particulars as to their type : *Belgian National, Danish State, Finnish State.*

The *French Est* makes use of ratchet spanners in order to effect the tightening more rapidly, whilst the *French State* uses at the start of the operation, short spanners (about 0.25 m. [9 7/8 inches] in length) whose manipulation is easy, and longer ones (about 0.70 m. [27 1/2 inches] in length) to accomplish the final stages.

The *Nord* Railway uses experimentally ratchet spanners of the Somax type made by Messrs. « Les Fils Peugeot ».

The *Netherlands* Railways limit the length of their spanners to 0.65 m. (25 5/8 inches) in order to avoid excessive tightening.

k) *Cutting and drilling the rails at the site of the work.*

The cutting of rails on the spot is usually done by hand for only the Buenos Ayres Western uses circular saws or mechanical hack saws for important renewals.

Mechanical drilling is in more general use. The *Buenos Ayres Western* uses a power drill actuated by a « John Bull » petrol motor, the *Central Argentine* and the *Belgian National* Railways also have adopted it and are beginning to use drills made by the firm « Electricité et Electromécanique » ; the *French State* Railways use power drills when the number of holes to be drilled justifies the use of such machines. Although normally making use of hand drilling, the *North of Spain* Railway in 1923 already used an outfit consisting of two electric drills with generating set when substituting angle fish plates with six bolts for flat plates with four bolts, on its line from Encina to Valencia and Tarragona, along a track length of 389 km. (242 miles). It also makes use of electric drills driven by a generating set for the purpose of fitting rail boards on electrified lines.

The following Companies use special hand worked drills :

The *Madrid-Saragossa-Alicante* Company uses machines of the « Buda », « Hyduty » types and the « Paulus track drill »; the *North of Spain* Railway for the fitting of rail bonds in connection with automatic block signalling; the *Danish State* and the *French Est* Railways for the rail bonds appertaining to track circuits.

In addition, the latter Company owns a travelling workshop (fig. 27) for the mechanical cutting and drilling of rails. It enables the rails of 46 kgr. (92.7 lb.

per yard) removed from trunk lines to be re-used on branch lines by cutting away 0.50 m. (1 ft. 7 11/16 in.) from each end in order to obtain new fishing surfaces, and afterwards re-drilling. The workshop is installed at the place where the rails are stacked.

The Paris-Orleans Company also possesses, probably for the same purpose, a mechanical outfit for cutting rails which have previously been collected at a suitable point.

1) *The laying of the track in the form of pre-assembled sections.*

The Companies which relay their track by completely assembled sections are seven in number. Among these are:

The *Swiss Federal* Railways who state that the assembling of the permanent way is usually done on the site of the work, and in certain cases only, which are not specified, sections of track corresponding to a pair of rails are transported as units.

The *Paris-Orleans* Railways do this on contract work but do not say in what form or according to what system.

The *Belgian National* Railways state that since 1918, they have experimented in transporting sections of track from 180 to 270 m. (590 to 785 feet) in length, assembling the different parts at the nearest station. The difficulties encountered have forced to abandon this system for work. They adopt, on contract work, the laying of pre-assembled sections, especially for the renewal of junctions and slip points in busy stations where sufficient space is not available.

The *Buenos Ayres Western* adopts, according to the description of the order for the execution of renewal works, the placing of the track by pairs of rails 12 m. (39 ft. 4 1/2 in.) in length, pre-assembled at a station and transported on flat wagons. The unloading and placing in the road are performed by means of cranes which lift out the old track and load it on wagons for removal.

The three *French* Administrations : the *Nord*, the *State* and the *Est* are those which, as a general rule, undertake relaying by pre-assembled sections of track.

The systems used, with minor variations, by these three Companies, are two in number : the Drouard system (figs. 28 and 29) and the Collet system, both of them being adopted by the *Nord* and the *State* Railways.

Drouard System. — This system was fully described in a « Note on the relaying of main lines by the use of mechanical appliances » by Mr. Tettelin, Chief Engineer for Works and Maintenance of the French Nord Railway, and which appeared in the *Revue Générale des Chemins de fer* (October 1929).

In this system, the conveyance to the site of the sections of track pre-assembled in the shops, is achieved by transporting them on flat wagons to the number of five sections 24 m. in length on each wagon (say 120 m. [394 feet]). Sufficient wagons are prepared to correspond with the length of the section of track to be relaid during the day; these are stationed on the same road which is to be renewed either before the particular length to be dealt with or on the part already relaid.

Beyond the section to be relaid and on the same road, there is stationed an equal number of wagons for the reception of the sections to be removed from the track.

On the road adjacent to that to be relaid, and between each batch of wagons, are stationed two travelling cranes for the purpose of lifting the pre-assembled sections of track. To enable this to be done each is provided with four frames having pivoted arms.

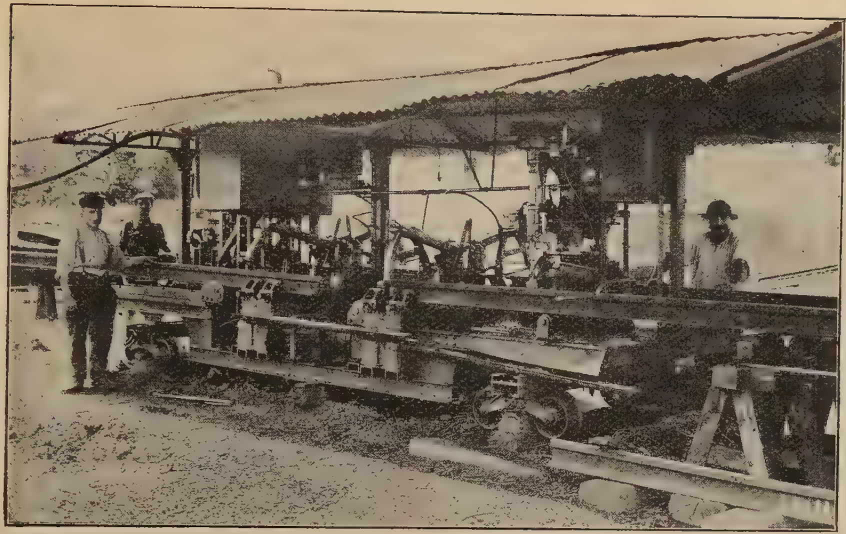

Fig. 27.

Fig. 28.

Fig. 29.

28 and 29. — Wagon provided with gantries for taking up or laying completely assembled track sections (Drouard system).

The power for the lifting and travelling motions is obtained from a petrol generating set which also provides current for lighting the wagon.

Between the two travelling cranes and on the same road, the Drouard screening plant is accommodated, constituted, as we have already seen, by four wagons (the screener, a wagon with a steam driven generating set, a tank wagon and another wagon with a petrol engine generating set). The work is carried out in the following manner : The first step is the removal of the old track in complete sections of pairs of rails by means of the first travelling crane and they are loaded one by one on to the empty wagons.

As soon as a number of rail lengths have been lifted out, the screener starts to function and removes all the ballast over the full width of the track to be relaid, the screen throws out the small laterally and spreads the cleaned ballast evenly over the formation.

The progress of this work is at the rate of 150 m. (492 feet) per hour; keeping pace with the spreading of the ballast bed, the other crane places thereon the pre-assembled sections of new track which it lifts from the wagons on which they have been brought to the site; the sections are coupled together and the road is in position.

This completed, the wagons in question are withdrawn and a ballast train formed of hopper wagons is brought up which tips along the whole stretch of track the necessary amount of ballast to compensate for screening losses and re-establish the normal profile of the track; finally the track is surfaced by packing with Collet machines.

As may be seen, this method entails the occupation of two roads, namely, that which is under process of relaying and the adjacent one for the travelling cranes and the screening machine.

This method was adopted for the first time by the *Nord* Company on the Paris-Chantilly line in 1929 between Saint-Denis and the La Chapelle-en-Serval junction. As there are four lines on this part of the railway, it was possible to cut out the service of through trains on the two lines to be relaid, for a length of 48.5 km. (30 miles). The whole of the traffic during the progress of the work (from 10.0 p. m. to 6.0 a. m.) was accommodated on the two local roads.

Minor modifications described by Mr. Tettelin in the *Revue Générale des Chemins de fer* (March 1931) (1), tending to reduce the period of occupation of the two roads, have enabled this method to be applied to double-line sections, at the price, however, of serious interruption to traffic.

These improvements consist : 1. In increasing the rate of advance of the screener from 150 to 180 m. (492 to 590 feet) an hour, for the progress of the work as a whole depends upon this factor; 2. In the use of special wagons for the direct reception of the waste material from the screener as already described.

It is in this manner that the relaying took place in 1930 of a length of 32.7 km. (20.3 miles) of single road on a double line between Ormoy and Longueau, and on a length of 8.7 km. (5.4 miles) of single road on the section from Orry-la-Ville to Creil, this also being a double line.

Whilst for the first of the renewals mentioned, progress was at an average rate of 600 m. (1 950 feet) daily for eight hours of work (from 10.0 p. m. to 6.0 a. m.), in the case of the first of the two last renewals, the average was 680 m. (2 230 feet), also for eight hours of work (from 7.0 a. m. to 3.0 p. m.); traffic was interrupted on the two roads for six hours out of the eight occupied by the work. During this time possession was taken of the road being relaid

(1) See also *Bulletin of the Railway Congress*, May 1932 number, p. 842.

and single line working was adopted during the last two hours on the remaining road.

This method is not, in any way, applicable to a single line.

Collet System. — This system has been used by the *Nord* Company according to the Loiseau procedure (described by Mr. Tettelin in the issue of May 1932, of the *Revue Générale des Chemins de fer*, and by the *Est* Railway (described by M. Patte, Chief Engineer of the Permanent Way Department, in the issue of April 1931, of the *Revue Générale des Chemins de fer*) with the exception of a few minor details.

The first step in the work is the removal and screening of the ballast by means of a Scheuchzer screener which has already been described, when dealing with the question. The new track is assembled and the old track is dismantled in a depot set up at a nearby station. The new track, previously assembled, is placed upon light wheeled frames of the width of the normal track, and fitted with ball bearings; then a train is formed of these elements of the new track which are transported by rolling along the normal track; the whole system is hauled by a tractor or motor trolley to the site of the work. There, a gantry mounted on trucks as described above, serves to place the new track and to lift the old one, which is loaded on the same apparatus on which the new track has been brought up, and the transport is performed in an identical manner as far as the assemblage depot. These gantries are placed along a temporary track of 3.20 m. (10 ft. 6 in.) gauge built upon blocks and leaving within it the track to be renewed; tackle is provided to enable the sections of track for renewal to be lifted and supported. There are other gantries which travel on the normal track and which serve to lift and carry, keeping time with the progress of the work, the temporary way for the gantry first mentioned. The whole of the plant is supplied by Messrs. Collet and the contractors for the work are Messrs. Dehé & Co., of Busigny (Nord).

This method was adopted in 1930 for the renewal of the permanent way and ballast on the line from Révigny to Vouziers, on a stretch of 6.4 km. (4 miles) between the stations of Antry and Ville-sur-Tourbe, and in addition on a stretch of 7.38 km. (4.6 miles) on the same line between the stations of Villers-Daucout and Sainte-Menehould.

In 1931, a scheme was in existence for the carrying out by the same system of :

40 km. (25 miles) of renewal of ballast only;

35 km. (21.7 miles) of renewal of track only;

18 km. (11.2 miles) of simultaneous renewal of both track and ballast.

In the two schemes carried out in 1930, the progress of the work was 368 m. (1 207 feet) daily with a working day of 7 h. 28 m.; seven gangers and 81 men were employed, and the assemblage depot was situated at an average distance of 4 km. (2.5 miles) away from the work. As regards the second, progress was 434 m. (1 424 feet) a day, with 10 gangers and 100 workmen, in spite of unfavourable weather, and it is calculated that, given better weather, an output of 500 m. (1 640 feet) per day could have been reached.

The *Nord* Company has tried the Loiseau-Collet method, possession of the road to be renewed being obtained for a period of 6 h. 15 m. (from 6.55 a. m. to 1.10 p. m.) of which only 4 1/2 hours were occupied in effective work, the site of the work being some distance from the depot station. In spite of this, the ouput was 244 m. (800 feet) daily.

m) *Weeding of the track.*

This is an operation for which the use of mechanical and chemical methods

— above all the latter — is fairly general. With the exception of the *Paris Ceinture* Railway, which does not state the method employed, out of 17 Companies sending replies on this subject, only 7 make use of mechanical methods, and three of these employ chemical methods at the same time. The *Swiss Federal* Railways use chemical methods of a more generalised character than the mechanical ones, which seem to be adapted to cases where besides rooting up the weeds, it is sought to clean the ballast and correct its alignment.

The weed-killer usually favoured is a 2 % solution of sodium chlorate. Three Companies, the *French Est* and *Nord* Railways and the *Netherlands* Railways use special products; the two first mentioned using Occysol and the last « Paraplant ».

The *Buenos Ayres Western* point out that they have tried herbicides in powder form, scattered by air pressure, but give no details.

The Railways using mechanical processes are :

Danish State Railways. — Use a machine towed by a locomotive.

Finnish State Railways. — The plant in use scarifies the ballast and pulls out the weeds outside the sleepers; the progress is at the rate of 6 km. (3.7 miles) an hour.

Bouches du Rhône Railways and Electric Tramways. — Have used a machine rented from its inventors « Société de Désherbage et de Piochage du Ballast des Voies Ferrées ».

Italian State Railways. — Weeding by hand and also mechanically by means of the Scheuchzer machine.

Netherlands Railways. — Use a machine of the « Karlsson », type drawn by a locomotive, which loosens the ballast outside the sleepers; the machine is described in the report presented to the Madrid Congress by Mr. Driessen [1]. The cost of the machine is 3 400 florins and it can cover 15 km. (9.3 miles) daily.

This Company has also carried out chemical weed killing using a 2 % solution of sodium chlorate and a product called « Paraplant »; satisfactory results have been obtained, but an annual treatment is considered to be insufficient, at any rate for the first year.

Swedish State Railways. — Use a machine built in their workshops at Orebro.

Grängesberg-Oxelösund Railway. — Has used mechanical methods, which have not given satisfactory results. Better ones have been obtained by yearly spraying with sodium chlorate. This treatment has given very good results on stone ballast, but not such good ones on gravel ballast.

Swiss Federal Railways. — Generally use chemical weed killing which is the most economical as regards cost. They use in addition as a mechanical method, the Scheuchzer weed-extractor (of Renens, Switzerland). This machine embodies three mechanisms capable of functioning separately or in combination. The first pulls out the weeds and loosens the ballast between the sleepers, across their entire length and irrespective of their spacing in the track. The second does the same work on the part of the ballast which is outside the sleepers and adjusts the alignment. The third enables the weeds to be removed from the six-foot way in the case of double track lines. Finally, a rotating rake placed at the back of the chassis separates the weeds from the ballast, surfaces the latter and cleans the sleepers (figure 30).

It the two first devices are working alone, or even together, the rate of progression of the work is from 8 to 10 km.

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(1) See *Bulletin of the Railway Congress*, February 1930, p. 385.

(5 to 6.2 miles) an hour. If the first mechanism functions alone, the rate is not more than 5 to 6 km. (3.1 to 3.7 miles)) an hour.

The machine operates whilst being propelled by a locomotive or a tractor and can be hauled, when out of action, at the speed of goods trains. Whilst in full operation it can be controlled by four men.

Chemical weed destruction is always done by spraying, the solution being contained in tanks of variable dimensions, whence it is forced into the sprayers by means of pumps.

Prince Henry Railways (Luxemburg). — Destroy weeds by means of hand spraying machines.

The Companies operating weeding equipment of importance, are :

Belgian National Railways. — The train comprises a tank whose capacity is 40 000 l. (8 800 Br. gallons) for holding the herbicidal solution, spraying apparatus, wagons containing the appropriate salt, dormitories, a kitchen and a workshop. They use sodium chlorate.

French Est Railway. — Also uses a train comprising a store wagon, a tank for the preparation of the solution, a tank-wagon, a sprayer and a van for the crew. They use sodium chlorate and Occysol (figures 31 and 32). They also employ small plants consisting of a tank-wagon and sprayer which operate attached to a train.

French Nord Railway. — Uses weeding trains consisting of a tank-wagon of 24 m³ (5 280 Br. gallons) capacity, equipped with sprayers, a flat wagon with a tank and a motor-pump set, for the preparation of the solution, and a covered wagon to carry a supply of the salt.

Spraying may be directed at will, either on the track proper, or on either side of the tire or on both of these at the same time.

A weeding plant is attached to each district of the railway. The materials used are Occysol in a 25 % solution, say 1 weight of salt to 4 weights of water, and also sodium chlorate. The latter is never used alone, but with the addition of an equal weight of the salt de-natured by means of sodium carbonate. This is mixed in the same proportions as the Occysol, that is to say, one kilogramme of the mixture of the two salts dissolved in 4 litres of water.

A colouring substance is also added which enables the weed-killing liquid to be distinguished.

The quantity of solution used for spraying varies from 60 to 80 gr. (1.77 to 2.36 ounces per sq. yard) for plants with short roots and from 80 to 100 gr. (2.36 to 2.95 ounces per sq. yard) for plants with deeper roots.

Midi Railway. — Uses a tank of 5 500-l. (1 210 Br. gallons) capacity which sprays 100 grammes of chlorate solution to every square metre, the apparatus moving at a speed of 20 km. (12.4 miles) per hour.

Buenos Ayres Great Southern Railway. — Uses a Magra machine from Messrs. Collet for spraying the 1 in 4 sodium chlorate solution. It sprays as required, on the track proper over a width of 4.20 m. (14 ft. 9 in.), or over a width of 0.60 m. (2 feet) on each side of each rail. The machine is pulled by a locomotive or it is attached to a goods train.

n) *Other mechanical processes.*

Buenos Ayres Western. — Refers to the undoing of the joints by means of « Young's patent hydraulic joint upsetter », but the information contained in the reply is not very clear.

Paris-Lyons-Mediterranean. — Carries out the initial drilling of sleepers by an electric machine which resembles the Collet coach screw driving machine.

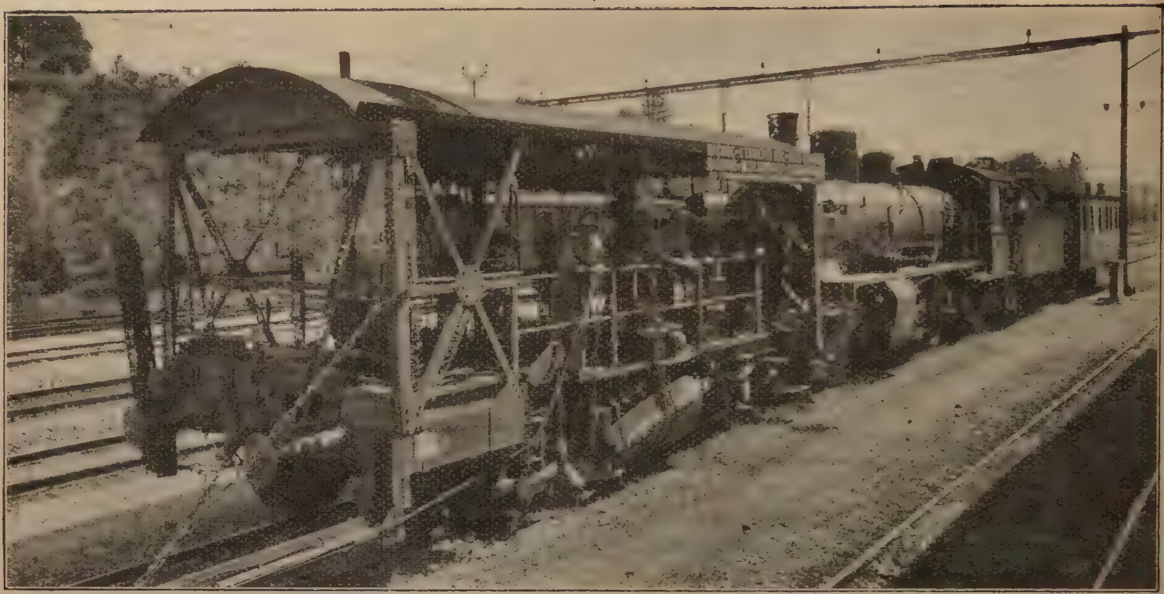

Fig. 30.

Fig. 31.

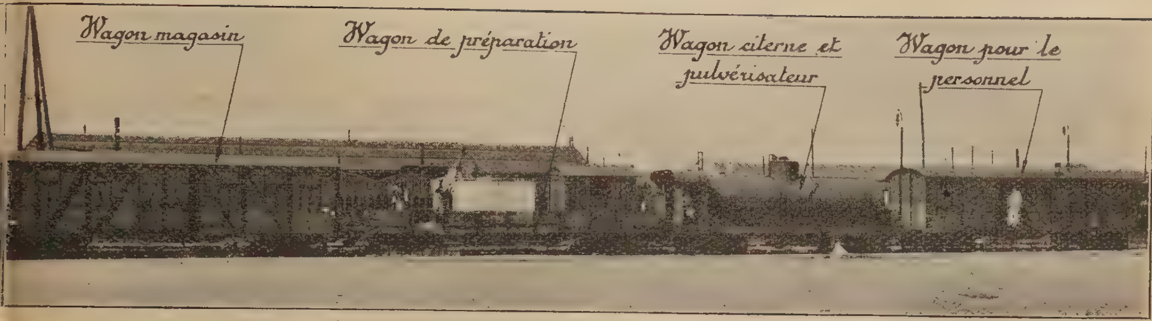

Fig. 32.

Explanation : Stores wagon. — Mixing wagon. — Tank wagon with sprayer. — Wagon for the staff.

French Nord. — Mentions the use of the Collet gantries for relaying rails.

The last two applications have been described in detail in previous paragraphs.

Questions 4 and 5.

Many Administrations have not replied to these questions. Several of the replies are expressed in very general, even vague, terms and bear in the aggregate upon all the various mechanical processes.

However, it is noticed that all the replies are unanimous on the following points, viz. :

1. Work performed by mechanical means is in general as good, and in certain cases, better than work performed by hand, especially as regards the cutting and boring of sleepers.

The *French Nord* intimates that mechanical operations such as ballast screening, coach screw driving, packing of sleepers, careful unloading of rails, as well as renewal by sections of track assembled in the shops, give a permanent way of *exceptional quality*.

The electric coach screw drivers and electric tampers in particular, produce a uniformity of work which gives to the permanent way a homogeneous character, thus rendering more durable the tightening of the coach screws as well as the surfacing and stability of the track, which, given equal traffic, has enabled the periodical repairs to be undertaken less frequently.

There is not a similar uniformity of opinion on the subject of packing. Whilst several Administrations (*Buenos Ayres Western* Railway, *French State* Railways and the *Paris Ceinture* Railways) claim that a more uniform packing is obtained mechanically — and the first of these Companies adds that they get more durable results — others (*North of Spain* and *Finnish State* Railways) are not completely satisfied with mechanical packing.

The *French Nord* Railway, also uses shovel packing with small ballast in maintenance work, thereby obtaining results at least equal to those obtainable by mechanical packing, with fewer workmen. Likewise the *French State* Railways point out that since the beginning of 1930, they have replaced, from similar motives, mechanical packing by shovel packing in maintenance work.

The *French State* Railways obtain greater efficiency by employing mechanical screening of ballast.

The *Madrid-Saragossa-Alicante* Company states that the use of special spanners for tightening fishplate bolts, gives good results in the laying of new track

and in renewal work, but in maintenance it is difficult to unscrew the nuts with spanners on account of rust.

According to those Administrations which use it, chemical weed killing gives satisfactory results, but according to the reports of the *Midi* and the *Netherlands* Railways, two applications annually are necessary.

2. All Administrations agree in recognising that with mechanical methods the work is carried out with greater rapidity. According to the *French Est* Railways these methods enable the saving of 50 % of the time in renewals and, according to the *Midi* Railways, 7.5 % in maintenance.

This great speed according to the *Belgian National* Railways makes it possible to reduce the number of workmen in the renewal gangs with the advantage of facilitating supervision of the works and of reducing risks of accidents, and, in the opinion of the *French State* Railways, of diminishing disturbance of traffic and costs of supervision of the work.

This advantage is above all noticeable in the cases of the coach screw drivers, the drills and chemical weed killing.

3. Information dealing with the cost of the work and its comparison with that of manual work is scanty, for many Administrations have stated that, as they have only adopted mechanical methods recently, they have not yet been able to draw up comparative figures. Other Companies indicate that a saving is obtained, but they do not specify how much.

According to the *Belgian National* Railways, an economy is obtained, with all the machines, provided they are used on a sufficiently large scale so that the maintenance and depreciation costs do not absorb this economy.

This does not agree with the opinion of the *Midi* Company, which has not adopted mechanical maintenance as a result of the trials undertaken, for it says that the boring of sleepers and the driving of coach screws — which represent two operations where there would be a real advantage over manual work — constitute a small fraction of ordinary maintenance.

The *Paris Ceinture* Railways believe that mechanical maintenance on a *large* scale would be economical as any loss of time would be avoided through its greater rapidity.

The *French Nord* Railway points out that the cost diminishes rapidly when the machines can remain for a longer time at work, without being obliged to withdraw them for the passage of trains. In this respect they are in agreement with the *Finnish State* Railways, who state that mechanical packing is not economical on a line carrying intense traffic.

The *Nord* Railway concludes that the increase in the daily output of work is the essential factor, which makes mechanical renewals more economical. As for daily maintenance, which will be examined in Part II, it is necessary to remember that an important source of economy comes from the greater interval of time which the mechanical work permits between two consecutive periodical surveys of the track.

Mechanical packing is an operation where the economic advantage is not so definite. For example, the *Paris-Lyons-Mediterranean* considers that it is economical only in the case when consolidation of the formation is necessary. In the maintenance of tracks in good condition shovel packing works out more cheaply.

The *North of Spain* Railways also state that mechanical packing is no cheaper than hand packing.

The mechanical operations for which we have precise facts are the following :

Special spanners for tightening the fish-plate bolts by hand. According to the *Madrid-Saragossa-Alicante* Company, the cost with Robel spanners is 0.0178 peseta per bolt and 0.020 peseta with an ordinary spanner.

For drilling rails, this same Company evaluates the cost per hole with a hand driven drilling machine at 0.037 peseta and at 0.166 per hole with the usual appliances.

In neither of these two prices has account been taken of the costs of maintenance and the depreciation of the machine.

The costs of mechanical work as supplied by the *North of Spain* Railways are as follows :

Adzing and drilling sleepers . . .	0.28 peseta per sleeper.
Coach screw driving	0.28 peseta per m. (0.084 peseta per lin. foot) of track.
Mechanical packing	0.70 peseta per m. (0.21 peseta per lin. foot) of track.

The *French State* Railways give the following comparative prices :

	By mechanical processes.	*By ordinary processes.*
Unloading ballast	0.50 fr. per m^3 *(0.38 fr. per cu. yard)*	3.50 fr. per m^3 *(2.67 fr. per cu. yard)*
Adzing and drilling of sleepers . .	1.75 fr.	3.50 fr.

The two Companies which give the cost of mechanical weeding are the *Midi* and the *Netherlands* Railways. The first estimates the cost at 0.05 fr. per m^2 (0.0418 fr. per sq. yard) and per application, two applications annually being considered necessary. The same result obtained by hand represents a minimum expenditure of 0. 30 fr. per m^2 (0.25 fr. per sq. yard).

Italian State Railways. — Maintenance work by means of compressed air tools results in a saving of 30 % as compared with work done by hand. This System states that no savings result from mechanical weeding.

The *Netherlands* Railways have made a comparison of price with sodium chlorate and with Paraplant in their reply for the Madrid Congress. They compute the work of hand weeding, carried out so as to give good results, at 0.575 florin annually per metre of track.

They state that chemical weeding with a 2 % solution of sodium chlorate is at 0.10 florin per metre of track and at 0.058 florin with a 5 %solution of Paraplant.

Although from these figures there appears to be no appreciable financial advantage, it seems that there may always be that of less time taken and the smaller number of workers necessary.

Summary of Part I.

Questions 1 and 2. — Although there are presented in the appendix, part I, the particulars furnished by the various Administrations, in a condensed form so as to facilitate their study, we will proceed to examine them in some detail, arranging them by questions.

After reading the replies, it may be said that permanent way maintenance with mechanical appliances is still in the experimental stage in the Administrations. It is not possible, in consequence to draw the same categorical and informative conclusions which might have been available from works carried out during a long period of time and on a large scale.

Mechanical processes are resorted to in a definite manner, especially for maintenance, only by the *French Nord* Company.

A great diversity of opinions is to be observed. Several Administrations use mechanical methods only for maintenance work proper. Others, on the contrary — and their number is in general greater — apply them to renewal work. There are finally some Companies which apply them for both cases, by contract when renewals are required and without adopting them for maintenance work only.

In a very general way, for mechanical work, internal combustion motors are used as the source of energy which is subsequently applied by electric motors. On electrified lines, electric current is used either directly or by interposing a transformer.

As will be seen, in respect to maintenance work, mechanical methods predominate in the following operations : preparation of the sleepers, packing, tightening of coach screws, transport and cleaning of ballast. As has been stated, it is the French Nord Company which applies these methods in the most definite manner.

In renewal work, the cleaning and screaning of ballast, the preparation of sleepers, the tightening of coach screws, packing, and laying of pre-assembled sections of track are also carried out by mechanical means.

Question 3. — a) *Transport of ballast :* For the transport of ballast, special wagons, with apparatus for lateral or central discharging are frequently used; these may be hopper wagons, or of a type similar to the ordinary wagon. This practice is very general and gives quite satisfactory results.

b) *Unloading of rails :* Various methods for unloading rails have been tried : fixed gantries at the ends of the wagons, jib cranes and winches, cranes forming part of the wagons or mounted on them; but it may be affirmed that the results obtained have not been completely satisfactory, and although considerably used, these systems may be considered as being still under trial. Only the *French Nord* Company furnishes a report absolutely favourable to the system practised by it, but it is not possible to recommend in a sufficiently sure manner any of the processes adopted.

c) *Screening of ballast :* Operation much resorted to, use being made almost solely of the Drouard or Scheuchzer machines.

In order to use them in a rational and economical manner, these machines ought to be employed on double-line sections. In this manner they give an excellent result not only from the point of view of the work carried out, but above all from the point of view of cost.

d) *Tractors and motor trollies :* These are much used for hauling the work trains proper or units detached from them. Their power and type vary according to circumstances, as indicated in the replies. They are also used for the conveyance of personnel in small or large numbers, and such a practice is worth while and might be generally adopted.

e) *Unloading the sleepers :* In practice no mechanical method is employed for this operation, trials not having given satisfactory results.

f) *Consolidation of the lower layer of ballast :* Little has been done in this direction. A number of trials have been carried out in Switzerland and in Denmark wit heavy rollers, but according to the replies, their use is in no case considered necessary; the ordinary methods are considered sufficiently efficacious, that is consolidation of the ballast by the trains themselves.

g) *Adzing and boring sleepers :* These operations, generally resorted to, are carried out in the shops where the sleepers are prepared, or on the spot as the case may be. In countries where the lay-out of the line is very tortuous and where adzing and boring must suit dif-

ferent gauges of the rails, this operation does not offer so many advantages as for lines in countries where curves are easy and simple.

h) *Packing:* Is much favoured and gives excellent results, although for some considerable time the results of this operation were regarded as inadequate.

i) *Coach screw driving:* Is much used and with great success; for this work individual or common motors are used according to the circumstances.

j) *Tightening of bolts:* It may be considered that, up to the present, mechanical appliances have not been sucessfully used and this work continues to be done manually.

k) *Cutting and drilling rails:* Although this operation is very interesting and extraordinary rapidity and economy are obtained, it is not greatly employed.

l) *Laying the permanent way by pre-assembled sections:* According to the reports received, it may be stated that, in addition to the *French Nord* Company, where this method is used for renewals as a matter of general practice, the *Buenos Ayres Western,* the *French Est* and *State* Railways also use it and obtain good results. It is obvious that for satisfactory application, this operation requires the existence of a double track, or better still, of a three or four lines.

m) *Weeding:* It is to be recognised that this is very general in countries where growth is not so prolific as in Spain. The chemical process, highly recommended, is more widespread than the mechanical process proper.

Questions 4 and 5. — To sum up, it may be said that all the reports received welcome the principle of perfecting and speeding up permanent way operations, although, in reality, the financial question which was the subject of the last query, may not be thoroughly settled.

Those Administrations which have sent comparative data on this interesting aspect of the problem and which enable an opinion to be formed, are very few in number; they do not even supply figures or definite conclusions on the subject.

PART II.

Organisation of the work.

A. — Maintenance of the permanent way.

1. — *What is the organisation which has been established on your railway for the maintenance of the permanent way by mechanical methods?*

a) *Are the gangs in charge of the mechanical maintenance distributed uniformly along the line?*

b) *Are the gangs employed concentrated at suitably selected points?*

c) *In the latter case* b), *are the gangs uniformly distributed along the lines for examination, inspection and carrying out small maintenance jobs, retained?*

d) *Are these last-mentioned uniformly distributed gangs the same as those in existence before mechanical maintenance methods were employed. Have the methods adopted enabled the staff to be reduced?*

Give details regarding this reduction and the staff composing the gang at the present time.

e) *What is the number and type of the employees composing a gang for mechanical maintenance?*

2. — *Are the gangs occupied on any work other than that of the maintenance of the permanent way?*

3. — *Do the gangs carry out the maintenance of sidings at stations and of track appliances, or only the maintenance of the running track?*

4. — *What is the average length kept mechanically in repair by one gang on the main line?*

a) *Are the roads in sidings included in this length?*

b) *To what length of main line track corresponds a mile of road in sidings from the point of view of mechanical maintenance.*

c) *In the case where the maintenance and laying of points, crossings, etc. is done mechanically, to what length of main line track are these appliances equivalent?*

5. — *Is the number of workmen in a gang for mechanical maintenance constant throughout the year or is this gang composed of a restricted number of permanent workmen, supplemented by temporarily engaged workmen?*

At what time of the year is the effective strength increased?

6. — *Do the gangs for mechanical maintenance carry out their work on the system of a general periodical inspection or as the result of a special examination?*

In the first case, how often is a general inspection made?

7. — *Please describe the other in which the work is carried out by the permanent way mechanical maintenance gangs, detailing the work done by mechanical methods and that done by the ordinary methods.*

8. — *What is the length of the working day of these gangs? Is it the same as in the ordinary gangs?*

9. — *Are tables or graphs compiled showing the progress of work of each gangs?*

In what form are these documents compiled?

10. — *Has the cost of each of the following kinds of work been determined by means of direct observation?*

a) *renewing one metre of track.*

b) *packing one sleeper.*

c) *renewing one sleeper.*

d) *renewing one cubic metre of ballast.*

e) *weeding one metre of track.*

f) *general inspection of one metre of permanent way.*

g) *renewing one metre of permanent way.*

11. — *Has the time lost due to the passage of trains or to other causes been taken into consideration?*

12. — *How are the men composing the mechanical maintenance gangs, selected?*

What are the qualifications or grade of the employee in charge of the gang?

13. — *Is this work carried out by the Company's own staff or by contract?*

14. — *In the latter case, please explain how the inspection or supervision necessary to see that the work is done up in a proper manner is effected.*

* * *

Maintenance of the track.

Eleven Administrations only have replied to this part of the Questionnaire. Among these the *Netherlands* Railways and the *Swiss Federal* Railways state that they have no special organisation for mechanical maintenance. The *Paris-Orleans* Company has under consideration a scheme which is not yet in operation.

It can be said that the *French Nord* Company alone possesses an organisation for mechanical maintenance of the track, which began to operate in 1931.

On the other Systems which we are going to examine, there exists only the ordinary maintenance organisation which, however, carries out certain operations by means of mechanical methods, but no special gangs are created for this purpose.

The *Buenos Ayres Western* only does

mechanical packing as regard maintenance and only in special cases.

The gang of workmen responsible for mechanical packing with pneumatic machines comprises a foreman, an assistant foreman and 18 workmen. The strength of the gangs has not been reduced but an improvement in the standard of maintenance has been obtained. These gangs are concerned only with track maintenance works and mechanical processes are used solely on main lines.

The average length maintained by each gang with power tools is 12 km. (7.5 miles) of quadruple road and 25 km. (15.5 miles of double main line.

The number of men in a gang is constant. Supervision is exercised by the assistant engineer or by the inspector. The working day is eight hours as for the other gangs on manual work.

The progress of the work is recorded on weekly tables having marked at the head the number of the gang and of the motor set, the stations between which the work is being done and the dates between which the week is reckoned.

On this table is noted daily the date, the road on which work is proceeding, the location (kilometre posts), the quantity of petrol and oil consumed, the working hours, the times, in hours, during which the gang has been working and resting, the causes of stoppage of work (travelling of the gang, bad weather, damage to the motor set) and other observations.

At the foot of the table is entered a description of the work carried out during the week. Up to the present, no special qualifications are looked for in selecting the personnel for the mechanised gangs, which are made up of men in the service of the Company.

Central Argentine Railway. — Only packs mechanically and uses pneumatic machines.

Mechanical processes have enabled the strength of the gangs to be reduced, but the proportion in which this is done is not given. Twelve men and a foreman with one machine.

The gangs are concerned solely with maintenance work on main lines; they maintain 22 km. (13.7 miles of track; the number of men is constant throughout the year and they are given permanent employment. The duration of the day's work is the same as for the other gangs, that is, eight hours nominally, or four hours « effective work ».

For the mechanised gangs, the choice of personnel is made from the most experienced workers and the foreman is selected from the gangers.

Finnish State Railways. — Perform mechanically the alignment and weeding of ballast as well as the packing of sleepers.

The surfacing machine is operated by 4 or 5 workmen and a supervising foreman. This machine travels once a year over all the lines. The men operating this machine must do other jobs as the call for the machine is not constant throughout the year. The rate of progress is 6 km. (3.7 miles) an hour.

A comparison of cost has not been made between the mechanical and manual work, but the former is considered the cheaper.

The packing machines are operated by two men and perform the maintenance otherwise undertaken by platelayers. In general their use is not economical on lines carrying considerable traffic.

The day's work is eight hours and Company's men are employed.

Paris Ceinture Railway. — Mechanical packing and coach screw driving has been carried out experimentally, the organisation of the gangs not having undergone any modification and the ordinary routine of maintenance having continued as usual. The trials having been of short duration, they have not yet provided opportunity for direct observation as to the cost of each operation.

This work has been executed excep-

tionnally by contract and in the price account was taken of the losses of time caused by the passage of trains and the necessities of traffic movements.

The work was supervised by cantonal and district officers in whose territories the operations took place. This supervision was effected under the same conditions as for ordinary routine maintenance.

French Nord Railway.

Of all the Companies consulted, this is the only one which replies that since 1931, it has modified the track maintenance organisation by adapting it to the use of mechanical processes.

Organisation of the staff. — Until 1931 track maintenance was done by hand, using gangs of almost constant strength uniformly distributed along the line. A gang of six men, as a rule, being responsible for the maintenance of 6 km. (3.7 miles) of double-track line.

These gangs undertook the work on the principle of thorough periodical overhauls, performing the work each year on a portion of the main lines on their section, and a more cursory attention was given to the remainder of the length. The latter was limited to a rectification of the more important defects.

In addition, these gangs had in their charge the maintenance of the lines through stations and structures or appliances appertaining thereto; maintenance and lighting of signals, repairs to fences, gates, yards, platforms, water diversion. They supplied also the personnel required to replace crossing keepers, and the signal men, during their periods off duty on account of leave, rest or illness. Amongst all these duties, the overhaul of the main lines is carried out in principle exclusively with the aid of mechanical plant.

As we shall see later on, the work split up into several sections is carried out by concentrated gangs or groups which attend to the overhauling in a continuous manner on a given line or section of line, without taking into account the territorial limits of the former gangs.

These groups are formed by collecting together the gangs located on the section to be worked upon or on the section adjacent to this one. It is necessary to make up the strength by casual labour drawn from outside the railway.

This has led to there being left in each of the former gangs only sufficient men strictly required for the works mentioned above, which are not done by mechanised groups and for the supervision of the main lines, the relief of crossing keepers and signalmen. This organisation of the work, consequent upon use of mechanical appliances, has led to a reduction in strength of the former gangs, but no information is given as to the number of men and the length assigned to them.

Whilst in 1929, without mechanisation, they employed 5 226 permanent workmen throughout the whole year, assisted by 1 576 casual workers, in 1931 they carried out the maintenance programme with only 5 005 permanent and 131 casual workers.

The new organisation facilitates the work of the district officer, since the members of his gangs are to be found spread over a small number of working centres. This has led to it being considered possible to increase the territorial area of the district by reducing their number from 145 to 121.

For the same reasons, the number of sections has been reduced from 36 to 27 and the number of areas from 9 to 7.

The headquarters office decides each year the sections of line over which the mechanised gangs shall operate.

The period elapsing between two consecutive visits of the gangs (overhaul period) varies according to the condition of the lines, their age and the traffic.

The adoption of mechanisation is as yet too recent for the overhaul period to be definitely settled for each one of the various operations, but it is certain

that, thanks to the constant quality and the homogeneity of the work, the period will be longer than in the past. For example, it is agreed that in future, the tightening of the coach screws, which was previously undertaken twice yearly, may be done in general once every two years.

Carrying out of the work. — The desire to obtain a maximum output in mechanised maintenance has brought about the grouping of the work necessary for the overhauling into three different categories. This work is not performed simultaneously but independently of one another and by different gangs constituted as has already been explained.

The three categories of work are :

1. Overhaul of fastenings and joints with replacement of rails, fish plates and small material.
2. Renewal of sleepers.
3. Alignment and surfacing.

The operations are performed in the following order :

1. Inspection of rails, and joints. All the new material to be substituted for that found defective at the inspection is assembled in order that, at the appropriate time, it may be at the disposal of the gang responsible for the work to be done.

These operations are done without mechanical plant.

2. Rectification of fastenings and joints. The gang responsible for this duty checks the track, the tilt of the rails and the expansion gaps at the joints, replaces coach screws which are no longer effective, plugs old holes in the sleepers, adzes them afresh, substitutes the rails and fish plates previously got ready as a result of the inspection and connects up the joints.

The plant used by this gang includes Collet coach screw drivers. Those sleepers in which the screws will not grip when driven by the machine, even after ferrules have been inserted, are marked for replacement.

In like manner any defective fish plates or rails which have escaped detection at the preliminary inspection are marked.

3. Replacement of sleepers. Those sleepers, fish plates and rails reported as defective after the overhaul of the fastenings are replaced. This work, usually a minor matter, is performed without power tools.

4. Adjustment of levels and consolidation. This is carried out with the aid of Collet packers. Occasionally a certain amount of « measured » shovel packing is also done. In this manner the work of track maintenance is organised on the lines of the belt system in a workshop, where each gang prepares the work of the following.

The work is carried out in a similar manner in each of the gangs, the duties of which we examine hereafter.

Gang for the overhaul of fastenings.

The foreman finds and points out the work to be done during the course of the day; such as timber to be adzed, gauge to be adjusted, rail inclinations to be corrected, joints to be renewed or to be tightened up.

With electrically-driven machines the coach screw men remove the screws and the timber men, using adzes, reface the bearing surfaces as necessary.

The coach screw men, starting at the beginning of their section, tighten the screws and extract those that are lose.

The adzers, now back at their starting point, distribute and prepare plugs, ferrules and coach screws. The coach screw men, now, tighten up the new coach screws and earmark those sleepers no longer capable of holding the coach screws. These sleepers, after examination by the foreman, are marked so as to enable them to be replaced by the succeeding gang.

This typical organisation, applicable to the general case of roads about twenty years old, which require new surfacing of the timber and the renewal of the sleepers, comprises ten men, — a foreman, a mechanic, two coach screw men and six timber men.

The machines used by the gang are :

An electric generating set.

Three coach screw driving machines (of which one is in reserve).

A monorail truck (figs. 33 and 34).

A stores truck for the distribution and collection of small material (fig. 35).

This type of organisation may be altered according to the work to be done.

When, for example, the adzing is of minor importance, the first visit of the coach screwer is omitted, and the extraction of screws at the places marked is done by hand.

In general, on new roads less than 15 years old, only the tightening of the coach screws is attended to. In this case the strength of the gangs is not more than four men.

Surfacing gangs.

The modus operandi depends on whether it is a question of a general surfacing of the road or merely a maintenance surfacing.

In the first case, operations are started at a high place and by the help of boning rods and all the sleepers are packed.

In the second case, only the low places are lifted in addition to badly seated sleepers. There is no strict demarcation between the two ways of working. The same gang may perform the two kinds of work during the same day.

The normal gang comprises thirteen men : a foreman, a mechanic, two men for the jacks, one man for bedding the track and eight for the rams or tampers.

The machines used by a gang are :

An electric generating set.

Two electric motors with ten tampers (8 in service 2 in reserve).

Six lifting jacks.

One monorail truck.

One levelling truck used for levelling purposes and for carrying the jacks (fig. 36).

As already mentioned, surfacing is also performed by means of « measured » shovel packing, which is in the hands of separate gangs normally containing six men. 540 of these gangs were at work in 1931, as well as 25 surfacing gangs with mechanical equipment.

Duration of the day's work.

The length of the day's work for the mechanised gangs is the same as that for the ordinary gangs.

Reports on the progress of the work.

The work done by these gangs is controlled from headquarters, by means of daily reports drawn up by the officer in charge of this work, with respect to the gangs overhauling fastenings, and also to those engaged upon mechanical packing and « measured » shovel packing.

For the drawing up of these reports, printed forms are used on which are entered : the line where work is in progress, the number of men in the gang, section or length worked over during the day, type of track, kind of work performed and materials used for each variety and finally any damage caused to plant and any remarks.

At the foot of the form is entered the duration of the day's work and the number of trains using the two roads. The area office, with the help of printed forms prepared for the purpose, draws up a report for each of these gangs. It shews the section and the period of

Fig. 33. — Transporting 27 fishplates weighing 23 lb. each.

Fig. 34. — Transporting 3 sleepers of 176 lb. each.

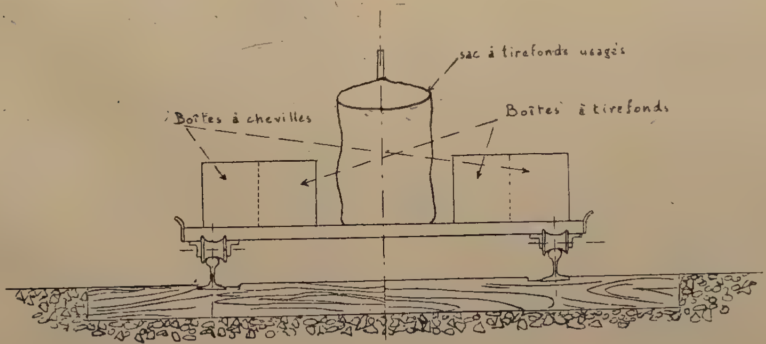

Fig. 35.

Note : Boites à chevilles = Bins for plugs. — Sac à tirefonds usagés = Bag for worn coach screws. — Boites à tirefonds = Bins for coach screws.

Fig. 36. — Levelling truck being used for transporting the implements.

working, and condensed in the form of a table, the work executed.

Cost of the work.

It would be possible to deduce the price of or more exactly the time devoted to each operation of the overhaul from these bulletins or reports, but as an initial undertaking, it was considered sufficient to deduce the mean costs of overhauling the main lines, calculated on the basis of the wages paid. In the following analysis, it will be observed that in the costs, allowance is made for loss of time caused by the passage of trains.

Gangs overhauling fastenings : 41 of these gangs have worked, in 1931, an average of 162.27 men-days, per gang.

The total number of wage units paid was : 72 225 wage units to workmen and 6 652 wage units to the mechanised gang.

The total length of track overhauled was 3 665.649 km. of single road, making 19 703 wage units to workmen per kilometre and 1 815 to the mechanised gang (31 708 and 2 921 per mile respectively).

Taking into account the maintenance charges and the working costs, the unit of wage to the mechanised gang is equivalent to 1.63 workman's wage units and, on reducing the wages of the gang to workman's wage units, we find that the cost of overhauling the fastenings is equivalent to 22.48 workmen's wage units per km. (36.18 units per mile) of track.

Mechanised surfacing gangs : 25 gangs using mechanical packers were on this work in 1931, involving a total outlay of:

54 813 wage units to workmen and
4 099 wage units to the mechanical gang.

The average number of working days per gang was 163 098, with which a length of 1 033.513 km. of single line was worked over, resulting in an expenditure of 53 036 wage units to workmen and 3 967 wage units to the mechanised gang for each kilometre of line (83 351 and 6 384 per mile respectively).

Taking into consideration the costs of operation and maintenance, one wage unit of the mechanised packing group is equivalent to 2.01 workman's wage units.

On converting the whole into workmen's wage units, we find that the mechanical overhaul of the surfacing is equivalent to 60.99 workman's wage units

per km. (98.15 workman's wage units per mile) of track.

Gangs for surfacing by « measured » shovel packing : As a data suitable for comparison with the preceding results, we will mention the output obtained in 1931 for track surfacing by means of « measured » shovel packing.

In 1931, 540 gangs carrying out « measured » shovel packing were engaged representing a total of 151 291.2 workman's wage units. The length of track treated was 5 271.925 km. working out at 28.697 workmen's wage units per kilometre (46.18 per mile) of track.

To these prices must be added those for the purchase and unloading of fine gravel, which, per kilometre of single track, represents 8.476 workman's wage units (13.64 per mile).

The adjustment of the surface for one kilometre of single line by measured shovel packing, comes to a total of 38.697 + 8.476 = 37.173 workman's wage units (59.82 per mile).

In these prices account is taken of time lost due to the passage of trains, breakdown of the plant and other causes, because they are deducted from the effective work performed by the whole of the gangs, as well as from the total number of wage units absorbed by the gangs.

In the above figures, the maintenance of the track by mechanical plant was carried out by staff and equipment belonging to the Company. The organisation of the work — established as a result of the utilisation of mechanical plant — is such that the head office is the one which determines the programme of work, instead of leaving this responsibility to more junior local officials. The work can thus be controlled and the costs established.

Paris-Lyons-Mediterranean Railways. — Do not possess an organisation for mechanical maintenance only. The operations which are performed mechanically are entrusted to mobile gangs whose organisation is in each case adapted to the circumstances.

Such gangs are not employed upon tracks through stations. They are used for work upon points and crossings only in special cases. Anything from one to six mechanised gangs are allocated to each area; these reinforce as necessary the maintenance gangs which retain the same composition as before.

Mechanised maintenance is adopted as permanent practice, but only when the length is sufficient to justify the losses of time and the costs of displacing the gang and the mechanical appliances.

The method of carrying out the work and its sequence is as follows : the track is excavated and then lifted, the levelling of the marker points is proceeded with and the alignment of the rails, all this being done by hand, using ordinary methods. Next comes the mechanical packing gang which lifts the track at intermediate points and pack all the sleepers.

Immediately afterwards, the coach screw driving machine comes and tightens all the screws and the manual gang which uncovered the track then tightens the fish bolts and finally boxes in the road with ballast.

The day's work is the same for all the gangs, manual or mechanised.

In order to record the progress of the work, forms are used of a simple nature to relieve the personnel of the gangs of as much clerical work as possible. On these forms are entered daily the kilometric positions of the ends of the section under mechanical treatment, the number of metres overhauled and the number of workmen employed, as well as mishaps to the machinery. Graphs are not prepared.

The work takes different times, according to local circumstances, and in view of the impossibility of regulating the duration of the day's work to be performed by each mechanised or ma-

nual gang, the costs of these various operations have not been determined. It is equally difficult to determine the losses of time caused by the passage of trains and by factors connected with other traffic requirements.

As to the choice of staff, only those in charge of the mechanised gangs are specially selected. They are recruited, for preference, from those who have spent their military service in mechanised units and, occasionally, from those who, without having any particular mechanical knowledge, show a capacity for this kind of work. For a week, the latter have practical experience with a chief constructional mechanic. The man having the control and supervision of this work ranks as a foreman.

Apart from the work executed departmentally with plant belonging to the Company, the latter has entrusted to contractors the mechanical execution of the general overhaul, principally on new lines, packing and coach screw driving being done mechanically with tools supplied by the contractors.

Inspection is exercised by tapping each day with the end of a crowbar all the sleepers packed the previous day. All sleepers which do not give the sound of a well bedded sleeper when hit must be re-packed.

As guarantee of the work, the contractor is required to carry out for a period of three months and at his own expense all the works which, in the opinion of the officials of the Company, are necessary to make good any irregularities noticed in the bedding and alignment after the passage of trains.

Italian State Railways. — The use of mechanical appliances has made it possible to reduce by 25 % the strength of the gangs which are uniformly distributed along the lines and carry out such maintenance work as is found necessary when walking the length. The cantons which were 7 or 8 km. (4.3 to 5 miles) long, now extend over 14 km. (8.7 miles) on the average and are made up of a foreman and 10 workmen. The strength of the gangs entrusted with the mechanised maintenance work is 60 to 65 men and they are made up of the men composing the gangs of the cantons in which the work is carried out, to which are added the neighbouring gangs, reinforced, if necessary, by temporary labour.

A gang provided with mechanical equipment carries out the revision of 180 km. (112 miles) of running track, with a yearly output of 90 km. (56 miles). Graphs are drawn up on which are mentioned : the materials renewed, the number of men making up the gang, the quantity of work done as regards adzing, boring and packing sleepers and the consumption of fuel and lubricants.

Grängesberg - Oxelösund Railway. — Uses only special wagons for ballast and for mechanical and chemical weeding. This work is done by special gangs made up of Company's men and under the orders of a permanent way foreman. This work is done during the summer.

Summary of Part II-A.

Track maintenance.

In the appendix, part II-A, are summarised the replies received in respect to this part of the question. We, however, point out hereafter such information as seems of great interest. It will be noticed that nearly the whole of the data originates from the *French Nord* Company which so far is the only one, amongst the Administrations covered by this report, to possess a complete and definitive organisation for mechanical maintenance work.

Question 1. — The *Buenos Ayres Western*, the *Central Argentine* and the *Finnish State* Railways have organised several gangs for the purpose of track maintenance, especially for packing, and the last of these Companies for trimming and weeding the ballast.

On the *Buenos Ayres Western* the special gangs, intended exclusively for this work, comprise a foreman, an assistant-foreman and 18 men who pack the road on a length of 25 km. (15.5 miles) of double-track lines and on a length of 12 km. (7.5 miles) of lines with four tracks. On the *Central Argentine*, the gangs include a foreman and 12 men for the packing of sleepers on a length of 22 km. (13.7 miles). Whilst the first of these Companies has not reduced, as a result of this new organisation, the number of workmen which it formerly had for the manual processes, the second has done so, but does not indicate to what extent.

The *Paris Ceinture* Railway has applied experimentally and without altering the gangs, mechanical sleeper packing and coach screw tightening, having in one instance only, and in order to make a trial of this new process, entrusted, as an exceptional step, this work to a private undertaking.

As we have already pointed out several times, the *French Nord* is the only Railway which has modified generally its original organisation since 1931. It has instituted mechanised working on its main lines, but does not clearly indicate the number of workmen composing the special gangs which have been formed for such work and recruited from the regular members of the original gangs. The *Nord* points out that the new arrangements made for the organisation of the work, have permitted in particular, to dispense with much casual labour, by reducing its numerical strength from 1 576 to 131 and reducing the number of territorial divisions, previously existing, to the following extent :

Districts : from 145 to 121.
Sections : from 30 to 27.
Areas : from 9 to 7.

Paris-Lyons-Mediterranean. — The Company has not instituted a special organisation for mechanical maintenance, and the operations performed by such methods are in the hands of mobile gangs of varying constitution, and adapted to the requirements of local conditions.

Question 2. — From the small number of replies received, it may be said that in general, the mechanised gangs are employed exclusively upon track maintenance.

Question 3. — It may likewise be stated that they are employed only upon the maintenance of the running tracks.

Question 4. — No definite replies to this question.

Question 5. — The number of regular workmen in this gang is constant; on certain occasions the number of auxiliary workmen alone varies.

Question 6. — Generally, the work is based on the system of a general periodical revision; the frequency is varied according to the state of the line, its age, and traffic conditions; the use of these processes is still of too recent date to determine the periodicity of overhauls.

Question 7. — The *French Nord* Company has described in a detailed manner, the sequence of the operations.

Question 8. — The duration of the working day is the same as for the ordinary gangs.

Question 9. — Reports are prepared for forwarding to the headquarters, on which is set down all the information necessary to indicate the progress of the work.

Questions 10 and 11. — In referring again to the report of the *French Nord* Company, it should be pointed out that, in the preceding pages, there has been given the cost of the various mechanised operations, not in money but in working days; we will recapitulate below the particulars already recorded, allowance having been made, in determining the

wages, of time lost as a consequence of passing trains and all other circumstances :

Overhauling fastenings : each kilometre of track requires 22.48 wage units (36.18 per mile).

Surfacing : each kilometre of track requires 60.99 wage units (98.15 units per mile).

Surfacing by shovel packing : each kilometre of track requires 37.173 wage units (59.82 units per mile).

No other data being available, it is not possible to compare these prices with those of the corresponding operations done by hand.

On the *Italian State* Railways, the cost of each operation is as follows :

Renewing 1 linear metre *(1 foot)* of track : 13 to 14 lire *(4.26 to 4.59 lire)*.

Packing 1 sleeper : 1.50 lire.

Renewing 1 sleeper : 2.50 lire.

Renewing 1 m^3 *(cubic yard)* of ballast : 8 to 9 *(6.12 to 6.88)* lire.

Weeding 1 linear metre *(1 foot)* of track : 0.40 to 0.50 *(0.122 to 0.152)* lire.

Complete revision of 1 linear metre *(1 foot)* of track : 5.50 to 6.50 *(1.68 to 1.98)* lire.

Renewing 1 linear metre *(1 foot)* of permanent way : 18 to 20 *(5.48 to 6.09)* lire.

With mechanical appliances the latter cost is about 40 % less.

The work is carried out departmentally.

Question 12. — The reports received supply no information.

Question 13. — Effected, in general, departmentally; very exceptionally by contract.

B. — **Renewing the permanent way.**

1. — *What is the organisation employed on your railway for the renewal of the permanent way by the mechanical methods ?*

a) *Is this work done by the same gangs as those in charge of the maintenance, with suitable reinforcements ? In this case, what is the constitution of these gangs ?*

b) *Are special gangs provided, intended solely for this work and having headquarters which are moved according to the section of permanent way to be renewed ?*

If so, state their composition.

c) *In both cases, please state whether the effective strength of the gangs employed, when the renewal was not done mechanically, have been retained, or whether the number of employees engaged has been reduced.*

2. — *What is the average length of permanent way renewed mechanically by one gang ?*

a) *Are the tracks in sidings situated on the line included in this length ?*

b) *In this calculation, to what length of main line track does a kilometre of siding correspond ?*

c) *In the case in which the points, crossings, etc. are renewed mechanically, to what length of main line track is this work equivalent ?*

3. — *Please describe the order in which the work is carried out by the gangs during the mechanical renewal of the permanent way, specifying the work done by mechanical methods and, if the case arises, that which is done by the ordinary method.*

4. — *What is the length of the working day in these gangs ? Is it the same as for the ordinary gangs ?*

5. — *Are tables or graphs compiled showing the progress of work in these gangs ?*

If so, please state in what form these documents are drawn up.

6. — *Has the cost of each of the following kinds of work been determined by means of direct observation :*

a) *Renewal of one metre of rail;*

b) *Packing one sleeper, indicating the type of packer employed;*

c) *Renewing one sleeper;*

d) *Renewing one cubic metre of ballast;*

e) *Renewing one metre of permanent way.*

7. — *Has the time lost due to the passage of trains or to other causes been taken into consideration?*

8. — *How are the men composing the mechanical renewal gangs selected?*
What are the qualifications or grade of the employee in charge of the gang?

9. — *Is this work carried out by the Company's own staff or by contract?*

10. — *In the latter case, please explain how the inspection or supervision, necessary to see that the work is done in a proper manner, is effected.*

* * *

The Administrations which have furnished data are by no means numerous. The majority of the Administrations, among whom are all the French Companies, entrust mechanical renewal to private undertaking. The remaining Companies perform it departmentally with special gangs composed of several regular men and of foremen of the maintenance gangs, with the addition of other men transported to the different points of the work and lodged in camps, or as is more usual, recruited in the district where work is proceeding and consequently changing with the work.

Buenos Ayres Western. — The work of mechanical track renewal is done by mobile gangs which assemble at the working place and are lodged in camps.

The number of men in these gangs has not been reduced by comparison with the number in the manual gangs, but the daily output of work has been increased.

In spite of this, the mechanical laying of the track is not a financial success except in special circumstances.

The length of track prepared is about 400 m. (1 312 feet) per night (in four hours) with 65 men.

Mechanical work is applied only to the renewal of running tracks (not including roads in stations).

The work is performed by assembling completely, in the depots, and by hand, the new permanent way by pairs of rails 12 m. (39 ft. 4 1/2 in.) long. These sections are loaded on flat wagons, there being 7 pairs of rails to a wagon.

Special trains of loaded and empty and ballast wagons convey the sections of track to the site of relaying. The old track is lifted out in pairs of rails with sleepers and loaded by means of cranes on the empty wagons. The new track is unshipped by crane and placed in position. During this time the necessary ballast is discharged from hopper wagons.

The progress of this work depends on the rate of opening up the road and cleaning the ballast.

The mechanised operations in this work are: the adzing and boring of sleepers on the site of the relaying and packing with pneumatic appliances. This method requires the possession of two roads, the one which is being relaid and the other for the relaying train.

The working day is of the same duration as for the other gangs; neither statements nor graphs are prepared to shew the progress made.

The personnel of these gangs is made up of casual labourers with the exception of the foreman and his assistant; the foreman has permanent first class rank.

The work, as a rule, is executed by the Company itself, but in certain cases, and for distant sections of the line, it may be let out on contract.

Inspection is undertaken by the engineer, by his assistant and by the permanent way inspector in whose district the work is carried out.

Belgian National Railway Company. — Does not possess any special organisation for mechanical renewals. The work is done by contract or by the Company. In the latter event, several gangs are equipped with an electric Collet outfit and, as a minimum includes, two coach screw driving machines. They have sometimes, in addition, two packers, one or two sleeper borers and a rail drill. The gangs have, in addition, trucks and a tractor for the transport of materials.

The relaying gangs are formed of temporary workers with a few platelayers, regular or temporary, but having some experience of this kind of work.

The temporary men belong to the gang attached to that part of the line to be renewed or to nearby gangs. The skilled specialist staff which looks after the machines is retained during the entire duration of the renewals and travels with the machines to the different sections receiving attention.

The concentration of the materials includes: unloading and stocking in a temporary depot (especially as regards the rails), then the transport on ordinary wagons by train to the site of the work. The sequence of the operations is as follows: opening up the track, taking out the old track, setting in place the new track, packing the sleepers, aligning and levelling, trimming the ballast and placing in position anti-creep devices.

In the case of cleaning or complete renewal of ballast, it is necessary to add: cleaning the ballast by fork or by screens, replacing the screened ballast, removing the waste material (either by loading into wagons or by dumping it on convenient waste land), unloading of new ballast and placing it in position.

Amongst all these operations, in the case of departmental work, the only mechanical appliances used are coach screw drivers, and Collet packers and electro-pneumatic drills.

As regards contract work, one contractor only used in 1931, a Scheuchzer ballast screener and machines for placing in position pairs of rails previously assembled in a neighbouring workshop.

The day's work, as for the other gangs, consists of eight hours. Progress statements are prepared for each of the elementary operations of the renewal work; these are brought up to date daily and the total progress is likewise indicated. Mention is also made of idle time due to bad weather, and of delays due to the running of trains, etc.

As a result of five years' experience (1926 to 1931), the time spent on the various operations has been determined as follows:

a) Renewal of a linear metre *(1 foot)* of rail: from 45 to 50 *(13.7 to 15.2)* minutes.

b) Packing of sleepers: from 250 to 350 sleepers per day of eight hours using two Collet packers with a total of nine men.

c) Renewal of one sleeper: 1 to 2 hours.

d) Renewal of 1 cubic metre *(1 cubic yard)* of ballast: from 4 to 8 *(3.06 to 6.12)* hours. In 80 % of the cases the time varies between 4 and 5 *(3.06 and 3.82)* hours.

e) Renewal of 1 linear metre *(of 1 foot)* of permanent way: 7 to 12 *(2.13 to 3.66)* hours (including ballast).

For the last three items, the time varies with the intensity of train traffic and whether the conditions are of a more or less favourable nature, such as the presence of narrow cuttings, passenger platforms, tunnels, etc.

In the times given, account has been taken of all time lost, as well as of the necessity of taking precautions at the site of the works, piloting of trains, etc., and all results refer to an eight-hour working day.

The figures sent by the Company, re-

presenting the time spent in the performance of the several operations as set down unter (a), (b), (c), (d) and (e) strike us as being rather excessive; we give them under reserve interpreting them in the sense that they refer perhaps to the times calculated according to the wage paid for their execution.

The personnel is chosen from among the most experienced of the regular men.

The skilled men operating the machines must possess some mechanical knowledge and, if possible, of electricity.

Renewal works are also carried out by contract, especially in those parts where labour is scarce.

The contractors have complete liberty in their methods of working, which, however, are submitted for approval to ths permanent way department. It does not often happen that mechanical processes are adopted, the case cited above is an exception.

The supervision of the work is exercised by the technical inspector of the zone assisted by his sectional inspectors and foremen.

In the case of certain important contracts a sectional inspector is appointed to be in constant attendance on the work. In other cases it is a head ganger who exercises permanent inspection, under the intermittent control of a sectional inspector.

Danish State Railways. — Track renewals are carried out by a special gang comprising a head and an assistant ganger, both on the permanent staff, several regular workmen from the local gangs reinforced with casual labourers from the district where the work is being carried out. For these gangs preference is given to men who have previously worked in maintenance gangs.

So far as possible, the same ganger is retained even if the section to be relaid extends over the lengths of several maintenance gangs.

The mechanical appliances used are : coach screw driving machines and packers. Their employment permits of a reduction in the number of workmen.

A gang can renew about 120 m. (394 feet) of track daily. The tracks in stations are not included in this work.

The working day is eight hours, as in the case of the ordinary gangs, in summer time nine hours are worked and the excess is compensated for in winter.

The work is performed by the Company's own men and with its own plant, without the assistance of contractors.

North of Spain Railways. — Do not possess any special organisation for mechanised renewal works; these are performed by contract. The Company's own renewal are done by hand with gangs composed of men from the maintenance gangs to whom are added casual workers from the district where work is proceeding and it is directed by a head foreman.

The average length relaid by mechanical methods is from 35 to 45 pairs of rails of 12.40-m. (40 ft. 8 in.) length, making from 400 to 500 m. (1 312 to 1 640 feet) daily.

In the work of mechanised renewal are comprised the station running tracks (excluding appliances), but not sidings.

Since track laying is the same outside and inside the stations, the mileage of the running lines in the stations is included for effective length.

The sequence of the operations is the following :

Adzing and boring of sleepers by means of a machine driven by an electric generator located at a point conveniently near to it. This work requires two workmen to operate the machine and from 7 to 9 to bring up and remove the sleepers, and a mechanic for the electric generator.

The distribution of material is effected by two sets of trollies, one for each gang constituted by a foreman and 24 men (12 for each set of trollies).

The opening up of the road is performed manually by a gang comprising a foreman and 25 men.

Placing the new track. — Is done by hand, placing the rails one on the outside and the other on the inside of the old road, and attaching eight sleepers per pair of rails; these sleepers are interposed between those of the old track.

As soon as 35 or 40 pairs of coupled rails are placed in this manner, the next step is to connect the old track with the new one, this is done once daily and taking advantage of an interval between the trains. Immediately afterwards the new track is slued, so far as possible, into its permanent alignment so that the trains can pass over it with certain precautions.

Next the old track is dismantled and taken out and all the sleepers required for the bedding of the new track are put in position with their sole plates.

This work is carried out by a gang composed of a foreman and 26 men. The coach screws are tightened by two Collet machines operated by two men, assisted by two others who bring up the coach screws.

Alignment and surfacing. — When the track is assembled, the ballast is put down and the reference points for lifting are packed (at the joints and in the middle of the rails); four men and a ganger do this work by hand, after which a pair of Collet packers — two pairs in certain cases — complete the packing.

The lifting gang consists in all of a foreman and 19 men.

When the track is lifted, the alignment is adjusted by transitioning the curves, the sleepers are boxed in with ballast which is then trimmed. These operations are done by hand and require 18 men.

The collection and removal of the old material is done, as in the case of the distribution, by the same gang.

Although the working day is of eight hours, the duration of the work extends to ten hours, the contractors arranging for several jobs to be done by piece work.

The cost of relaying is 6 pesetas per linear metre (1.83 pesetas per foot, including the distribution and removal of material, as well as maintenance of the new permanent way for a period of two months, as a form of guarantee.

Supervision is permanent and assured by two foremen; one supervises the laying and the other surfacing and aligning. In addition the permanent way district engineer pays daily visits and either the sectional chief or his assistant pay frequent visits to the work.

French State Railways. — Entrust renewals to contractors specialising in this work and possessing the necessary plant.

As has already been said, relaying is done by pairs of rails, previously assembled, according to the « Drouard » or « Collet » systems; it comprises the taking up of the road, the screening of the ballast, the renewal of the permanent way, and the initial maintenance of the new road.

The length of single track renewed daily is from 300 to 1 000 m. (984 to 3 280 feet).

The renewal of points and crossings and the station sidings is usually done by hand.

Supervision is untertaken by a man having the rank of permanent way inspector, assisted by several foremen who remain permanently on the works. The control of the work is entrusted to the district engineer concerned, aided by a works overseer, and inspection is exercised by the sectional chief, by assistant inspectors and by the head of the area concerned.

French Est Railway. — The renewal of the ballast and of the permanent way, using mechanical appliances for laying the track previously assembled by pairs of rails, instituted in 1930 and 1931, has

been entrusted to a firm which has supplied the screener and all the carrying plant, as well as the coach screw driving and packing machines, and has undertaken the laying of the permanent way and the removing of the old materials. The Company has provided the large gantries used in the shops for the pre-assemblage of the sections, also the means of transport, the loco-tractors and trollies.

This Company states, moreover, that material used, from the 23 March to the 28 April 1931, on the complete relaying work on 18 km. (11.2 miles) with replacement of rails of 44-kgr. (88.7 lb. per yard), rails 9 to 10 m. (29 ft. 6 1/2 in. to 32 ft. 9 3/4 in.) long by rails of 46 kgr. (92.7 lb. per yard), 18 m. (59 ft. 5/8 in.) long, was the following :

a) Assembling shops for track sections :
2 gantries with 5 ton-tackle.
2 electric coach screwing machines.

b) On the site of the relaying :
6 gantries with twelve track lifters for placing and removing the parts of the track sections.
6 gantries with twelve track lifters for shifting the trackways for the above mentioned gantries.

c) Means of transport :
2 loco-tractors, one of 40 H.P. and one of 100 H.P.
1 trolley of 30 H.P.

d) Ballasting and relaying :
1 group of Collet electric packing machines.

The personnel engaged was the following :

a) Assembling shops for new track sections:
1 foreman and 14 men . . . . 15 men.

b) Dismantling shops for old track sections:
1 foreman and 34 men . . . . 35 men.

c) On the site of the relaying :
Stripping gang :
1 foreman.
2 men for undoing joints.
6 labourers.

9 men.

1 foreman.
2 men for lifting.
2 men for making joints.
8 labourers.

13 men.

d) Opening up the road :
1 foreman and 22 labourers . 23 men.

e) Levelling and packing :
1 foreman.
4 packers.
14 labourers.

19 men.

f) Final revision :
1 foreman and 15 labourers . . 16 men.
Grand total for the whole job : 130 men.

In addition, the Company supplied :

g) For transport :
3 drivers for loco-tractors and trollies;
1 platelayer.

h) Safety precautions and signals :
3 platelayers.

The average length of track relaid was 600 m. (1968 feet) daily.

During three days, 900 to 950 m. (2 950 to 3 115 feet) daily was reached.

For the execution of the work, 10 hours (from 8.0 a.m. to 6.0 p.m.) were available, during which all train traffic was stopped.

This period was not wholly utilised on account of the regulations appertaining to the number of hours worked and the distance away of the workmen's lodgings.

General supervision was exercised by a district engineer.

Assembling and dismantling shops:

1 head permanent way overseer.
2 foremen.
1 assistant platelayer.
On the spot :
1 head permanent way overseer.
2 labourers.

On adding the latter to the personnel supplied for transport and the signals,

it will be seen that a total of 17 men was furnished by the Company.

The quality of the work was found to be distinctly superior to that performed manually.

Greater safety is achieved and no material is left along the line either before or after the renewal work.

French Nord Railway. — Renewal of the track with mechanical appliances is regularly effected by the « Drouard » and the « Loiseau-Collet » systems, of which the details and work organisation have been given in the first part of this report when dealing with the laying of pre-assembled track sections made up of a pairs of rails.

These renewal works, up to the present, have been confided, after calling for tenders, to contracting firms.

At the present time an attempt is being made to relay by another system by which the rails will no longer be transported in assembled pairs; this is being tried owing to the following considerations :

The mechanical tightening of coach screws requires defective material (sleepers and coach screws) to be replaced much more strictly than is necessary in the case of maintenance by hand; as a result the work must be maintained all the time in perfect condition.

Under these conditions, the renewal of the track does not necessitate the general replacement of the whole of the permanent way materials, as is the case with the « Drouard » and « Collet » methods, but it suffices simply to renew the rails as a consequence of, either wear, deformation of the joints, or lack of resistance under the ever growing increase of the stresses and of the traffic.

As a consequence of the preceding argument, and as an experiment, the *French Nord* Company intends to start, during the course of next year, the following mode of effecting renewals:

The first step will be the distribution of new rails, by arranging them on both sides in a continuous line on the sleeper ends (fig. 37) thus forming a track for the working of the appliances to be used, viz. : 1. gantries for raising the old rails and loading them on trucks (figs. 38 to 40); 2. adzing and boring machines for preparing the sleepers without moving them from their place (fig. 41).

This being done, the new rails which formed the temporary road are slued on to the sleeper rail seats (fig. 42) and are secured in position by means of Collet coach screw drivers (fig. 43). In this manner the replacement of the rails is effected.

If necessary, the spacing of the sleepers is then modified to agree with the arrangement required for the new type of road.

In the same way, the Scheuchzer machine may be employed if screening of the ballast in considered necessary.

The Company propose to execute this work, not by contract, but by its own gangs, composed of regular platelayers and organised on the lines of the mechanised maintenance gangs.

The working day and hours of labour for renewals by the Drouard method depend on the traffic conditions to which they are subordinated by the necessity of suspending the services on two tracks, which, on a double-track line, involves the stoppage of all traffic at certain intervals.

In general, the duration of the working day is eight hours; it has been six hours in certain cases.

The average length of track renewed was 600 m. (1 968 feet) in 8 hours with a gang of 21 men. On some sections it reached a daily average of 600 m. (1 968 feet) in 8 hours of work and on others 403 m. (1 322 feet) in 6 hours.

Fig. 37.

Fig. 38.

Fig. 39.

Fig. 40.

Fig. 41.

Fig. 42.

Fig. 43.

When this work is done by contractors, the contract includes a series of prices applicable to the diverse unitary operations for the renewal of the track. These prices (not given in the reply) may be increased, depending on the intensity of the traffic on the lines to be renewed.

There exist also lump sum contracts with a single price applicable to a linear metre of track renewed, the price being subject to modification when the actual progress of the work departs materially from the theoretical output arranged for in the contract.

In order to ensure the proper carrying out of this work, inspection is usually provided by appointing to the contract a district engineer during the whole duration of the contract. The district engineer is assisted by overseers attached to each of the individual processes.

Paris-Orleans Railways. — Up to now, renewal by mechanised processes has only been carried out in exceptional cases and always by contract, under the supervision of the Company. Moreover, the contractor must maintain the new permanent way for a given period (no information is forthcoming as to this period nor as to the persons responsible for supervision).

Paris-Lyons-Mediterranean Railways. — Renewals are usually carried out by contractors. They are only done by the Company in exceptional cases where short lengths are concerned and when the maintenance gangs can be employed for these works without risk of their normal duties being neglected.

Small renewals are not carried out mechanically, their inconsiderable length not justifying the use of mechanical equipment.

The contractors have full liberty to use the methods they consider best, but the Company reserves the right to prohibit those whose results have proved unsatisfactory or damaging to the equipment.

Inspection is arranged as for manual work; in both cases every day all sleepers packed on the previous day are tested by blows from the end of a crow bar. The guarantee and maintenance required from the contractors is three months; the same period applies to maintenance works proper.

Algerian State Railways. — Have only quite recently adopted the practice of putting mechanised maintenance to contract.

Swiss Federal Railways. — Have no gangs specially employed on track renewal. This is generally carried out by lump sum contracts.

The whole of the material is distributed along the line before the start of the work.

In general, on double track lines, the traffic is stopped on the track to be renewed and the sequence of the operations is as follows:

1. Opening up the track and screening the ballast with Scheuchzer screeners.
2. Dismantling by hand the old track.
3. Consolidation of the old ballast after screening, with a 4 to 6-ton roller.
4. Placing of the second layer of ballast, and consolidation with the roller.
5. Assembling by hand the new track.
6. Transport of the ballast, mechanical unloading and spreading between the sleepers.
7. Packing the sleepers with pneumatic tampers; in part, by hand, if needed.
8. Levelling and aligning of the track.
9. Loading and conveyance of the old materials, with trollies drawn by motor tractors.
10. Loading by hand and, if necessary, transport of the rubbish from the screening of the ballast.
11. Final trimming and adjustement of the permanent way.

If the line is single-track, or if, in the case of a double-track line, the track to be renewed must remain in service, the work is usually done by night.

The sequence of the operations is the same, with this difference that, in general, all the old ballast is removed without being screened, but in all cases consolidation of the roadbed and of the first layer of new ballast is carried out by means of the roller.

The legal length of the working day is eight hours; it varies from 8 1/2 hours in summer to 7 1/2 hours in winter.

The cost of renewing one linear metre of permanent way, including ballast, is from 11 to 14 francs (3.05 to 4.26 Swiss francs per foot) (excluding the value of the materials). In fixing the price in the contracts, consideration is paid to the losses of time caused by traffic if the road to be renewed is in service during the work.

Inspection of the works is permanent. It is exercised by the head of the district or his assistant and it is carried out according to detailed instructions relative to the work to be undertaken.

It is inspected periodically by the permanent way engineer.

Summary of Part II-B.

Renewing the permanent way.

In the appendix, par II-B, will be found, in summarised form, the information received as regards this part of the question.

The more interesting particulars will, however, be mentioned hereafter; as already stated, the *French Nord* Railway supplied the most interesting part of the information.

Question 1. — In general, track renewal is carried out by contract. For this reason, the Administrations do not form gangs specially for this purpose; the *Buenos Ayres Western* Railway has established however flying gangs which are dispatched to the spot where the work is to be undertaken. Some Companies combine hand work and mechanical methods; amongst these is the North of Spain Company.

Question 2. — The lengths renewed during a day's work by the various Administrations are very variable; it seams logical to include, when recording the output, the losses of time occasioned by the greater or lesser difficulties which arise according as the circulation of trains is more or less intense. The data refer exclusively to running track (sidings excluded).

The lengths vary from 400 m. (1 312 feet) daily, in the case of the *Buenos Ayres Western* Railway, to 1 000 m. (3 280 feet) in the case of the *French State* Railway; on the *French Nord* Railway, the length fluctuates between 400 and 650 m. (1 312 to 2 030 feet).

Question 3. — The sequence of the various operations varies from one Administration to the other as has been stated above.

On the Buenos Ayres Western Railway, sections of track 12 m. (39 ft. 4 1/2 in.) long are assembled at the depots and transported to the site of the relaying; there, they are placed in position by means of cranes, after the sections of the old track have been removed by the same process.

The *Belgian National* Railway Company makes little use of mechanical appliances in this work; such is also the case with the other Administrations which do not carry out their relaying work entirely according to these methods.

Attention should be drawn to the fact that the *French Nord* Company, which up to the present date performed renewals by using sections of track completely assembled at a place away from their final position in the road, has now abandoned this system, at any rate partially. Whilst continuing to use mechanical appliances, this Company will make use of a new system previously described in detail; this system involves the placing, in proximity to the rails

to be renewed and parallel to them, of two lines of rails with a given gauge, for the purpose of serving as a runway for several of the mechanical appliances; the latter will eventually be utilised for placing the rails in question in their final position.

This information is interesting in the sense that it denotes a change of opinion which, on the part of a Company studying these works with much care and attention, merits that the results of the experiment should be closely followed.

Question 4. — Generally, the day's work is the legal 8-hour day; with some Administrations it is shorter in consequence of the difficulty of obtaining a period of time sufficiently lengthy for the completion of this work; on the contrary, in other Administrations, for which the available time is longer, days of 10 hours are worked, the excess over the legal number of hours being paid as overtime.

Question 5. — It may be affirmed that, as almost general practice, the Administrations which replied to our questionnaire keep neither graphical diagrams nor detailed statistical statements which enable the progress made to be followed accurately and to deduce from their examination interesting conclusions and comparative studies.

Questions 6 and 7. — The Administrations have generally sent few particulars of an economic nature concerning the cost of mechanised processes. This lack of information is regrettable for it is evident that, in parallel with the technical results, knowledge of the economic features is of real importance. The North of Spain Company alone mentioned, as the cost of renewals, a figure of 6 pesetas per linear metre (1.83 pesetas per foot) of track.

Question 8. — Those Administrations which have this work carried out by contract, and those are the majority, have not to select the personnel employed on this work. Accordingly they do not give any reply to this subject. Those Administrations which carry out this work departmentally, are accustomed to employ, with a nucleus of permanent personnel, some temporary workers, who, if possible, have specialised and are experienced in similar work.

Question 9. — With reference to the first question, it has already been pointed out that the work is done by private enterprise, and those Administrations doing it directly are few in number.

Question 10. — Inspection of the work, in the case of contracts, and their supervision in the case of work carried by Company's staff are ensured by senior officials : engineers, section supervisors, etc... who examine and check periodically the work being carried out.

SUMMARY.

Part I : Appliances used.

1. In spite of the number of years which have passed since a start was made in applying mechanised processes to the maintenance and renewal of the track, results have not yet been obtained of such a nature as to definitely encourage their use. In fact, it is difficult to account for this; it is not known whether the cause is imperfection of the machines or tools used, insufficient experience; since the adoption or the use of an insufficient proportion of these machines, perhaps because of the high first cost of the complete equipment.

2. The number of Administrations having definitely adopted mechanical methods for the maintenance of the track is very restricted. Moreover, the time which has since elapsed is so short that one cannot appreciate whether the results obtained are really representative. These results ought to be reinforced by further experience before they

can be taken as a basis to guide the decisions of other Administrations.

3. Although mechanical processes have been resorted to as much in maintenance work as in track relaying, the trend seems to favour them in the case of the latter work, which is preferably entrusted to private undertakings, whereas maintenance work continues to be carried out departmentally.

4. Amongst the various kinds of work capable of being performed mechanically, there have been tried for preference and have been, so to say, adopted, those relative to the transport and screening of ballast, adzing, boring and packing of sleepers and tightening of coach screws. The trials relative to the haulage of works trains (ballast, etc.) and the transport of materials as well as the laying of the track by assembled sections, are not in the same category, whilst those attempted for other operations may be regarded simply as tentative experiments.

5. Information of an economic order forwarded by Administrations is extremely scanty, whence the impossibility of attempting to establish firm conclusions as regards comparison between mechanised and hand work. There is every reason to hope that if a similar subject is taken up by the technical publications and re-introduced for the next Congress, a greater quantity of information will be furnished in order to enable a definite judgment to be formulated.

Part II : Organisation of the work

A. — *Maintenance of the permanent way.*

1. Those Administrations which have organised partially mechanised work for track maintenance, with the members of the gangs suitably chosen, are few in number. Only the *French Nord* Railway has adopted this method in a general manner since the beginning of 1931. Therefore, complete and positive conclusions cannot be drawn up.

2. According to the information supplied by the said Company, there is obtained, thanks to this system, an appreciable reduction in the number of men employed, particularly of temporary workers; it enables also the curtailment, to a large extent, of the fundamental nucleus organisations ; an evident economy results.

3. It is difficult to estimate from the data supplied — which do not include the working costs asked for — the economy obtained, not only for each operation taken separately, but also for the whole work.

Moreover, even if the missing information had been forthcoming, experience based on a single year's practice, starting from 1931, would not have justified the definite and general adoption of such processes.

4. The various Administrations which have already made trials, should be recommended to continue these extensively in order to be able to obtain, as standard practice, the adoption of mechanised work instead of hand work. Those which have not already made these experiments should undertake them so that their future replies may bring up fresh data and features for consideration.

B. — *Renewing the permanent way.*

1. Those Administrations which have organised mechanised track renewal works with their own personnel, suitably chosen, are few in number.

2. The renewals by mechanised methods are effected, almost always by private undertakings who specialise in this kind of work and with whom are negotiated contracts and agreements varying in nature according to the case.

3. It is difficult to indicate the economy resulting from the use of mechan-

ical methods, the data supplied being scanty, not only so far as the working costs with these methods are concerned, but also as regards the expenses previously incurred with the manual methods.

4. From the replies received, it may be inferred, or at least it appears that neither graphical records nor carefully kept statements are utilised with the object of following the progress of the work and of being able to deduce therefrom useful information. In view of their great utility it is to be hoped that the use of such documents will become more general.

5. It is worth recommending the divers Administrations, which have already experimented mechanised renewal work, to continue this with the object of bringing about the adoption and generalisation of mechanical work in place of manual work. Those which have not yet undertaken mechanised renewal work are invited to try it so that their future replies may reveal new facts from which useful conclusions may be drawn.

APPENDIX.

Summary of Railway Practices (Replies to Questionnaire).

Part I. — Appliances used.

1. — Does your Administration employ mechanical methods for the maintenance of its permanent way ?

Buenos Ayres Great Southern. — Yes. Packing (as a trial), adzing of sleepers and weeding.

Buenos Ayres Western. — Yes, locally.

Central Argentine. — Yes, packing on a small scale.

Cordoba Central. — Yes. Only for the transport of ballast.

Belgian National Ry. Co. — Yes.

Belgian National Light Ry. Co. — Yes.

Danish State. — Only for weeding.

Madrid-Saragossa-Alicante. — No.

North of Spain. — No. Only trollies in the electrified zone.

Finnish State. — Yes.

French State. — Yes.

Paris-Ceinture Rys. — Yes. Experimentally, by contract, using compressed air as motive power.

French Est. — No. Only motor trucks and trollies.

French Midi. — Experiments have been made on a section of track. At present they are not in use.

Paris-Orleans. — Yes, but only recently and experimentally.

Paris-Lyons-Mediterranean. — Yes; but the use of mechanised processes has not been general.

French Nord. — Has applied mechanised maintenance since 1931 with corresponding special organisation.

Bouches-du-Rhône Electric Rys. and Tramways. — No, only mechanical weeding.

Algerian State. — The application of mechanical methods has been stated.

Prince Henry (Luxemburg). — No.

Netherlands Railways. — In a small number of operations, but not generally.

Portuguese Railways. — Trials are going to be made.

Swedish State and Uppsala-Norrland (Sweden). — Yes.

Grängesberg-Oxelösund (Sweden). — No.

Swiss Federal Rys. — Mechanical appliances are used but not a complete system of mechanised maintenance.

2. — Does it employ them for replacing or renewing certain sections of the permanent way ?

In both cases by mechanical methods are understood those which utilise a motive force irrespective of its nature

(electric, pneumatic, etc.) for driving the machine tools. Please indicate the nature of the motive force employed and the means of producing it.

In the affirmative, please state whether their use is effected normally and in a definite manner, either for maintenance of for renewal, or whether they are being employed by way of trial.

In the latter case, please state whether the trial is being conducted in a permanent manner, as in ordinary maintenance, or whether it is an isolated trial applied in one or more isolated districts only.

Buenos Ayres Great Southern. — No.

Buenos Ayres Western. — Yes. The track is placed by pairs of rails ready-assembled.

Central Argentine. — No.

Cordoba Central. — No.

Belgian National Ry. Co. — Yes.

Belgian National Light Ry. Co. — No.

Danish State. — Yes.

Madrid-Saragossa-Alicante. — No.

North of Spain. — Yes. When important renewals are carried out by contract.

Finnish State. — No.

French State. — Yes.

Paris-Ceinture Ry. — No.

French Est. — Yes. In the organisation of the works, by putting the track in place by pairs of pre-assembled rails.

French Midi. — No.

Paris-Orleans. — In exceptional cases, by contract.

Paris-Lyons-Mediterranean. — On certain occasions and by contract, full liberty being allowed the contractor in the use of mechanical methods considered desirable.

French Nord. — Renewals are carried out with mechanical appliances, the road being placed by pairs of rails pre-assembled in the shops.

Bouches-du-Rhône Electric Rys. and Tramways (France). — No.

Algerian State. — Have been applied by contract to the renewal of a section of track.

Prince Henry (Luxemburg). — No.

Netherlands Railways. — No.

Portuguese Railways. — No.

Swedish State and Uppsala-Norrland (Sweden). — No.

Grängesberg-Oxelösund (Sweden). — No.

Swiss Federal. — Applied by the contracting firms who undertake renewals.

3. — For each case of application of mechanical methods, please give details of the machines and the methods employed, forwarding drawings and photographs and giving the price, make, makers or suppliers of the machines used and any other useful information.

Please state also :

a) whether wagons with special loading and unloading devices are used for the transport of ballast;

b) whether they are used for loading and unloading rails;

c) whether special machines are employed for screening the ballast;

d) whether small tractors hauling lorries are employed for the transport of materials;

e) whether the sleepers are unloaded mechanically in bulk or distributed along the section on which they are to be used;

f) whether the lower bottom layer of the ballast is rammed mechanically;

g) whether the sleepers are cut and drilled mechanically, and whether these operations are carried out on the spot where they are to be used or in the workshop before creosoting;

h) whether the sleepers are packed mechanically;

i) whether machines are used for tightening the coach screws. State whether this work is done in the shop — in cases where the design of the chairs employed renders this possible — or on the ground where they are to be used;

j) whether the tightening of the fishplate bolts is done mechanically or by hand.

In the latter case, are special spanners employed for carrying out the work quicker and easier ?

k) whether the necessary cutting and drilling of the rails on the ground is done mechanically;

l) whether sections of track consisting of a couple of rails with chairs, sleepers, etc., are completely assembled and then transported to where they are to be used and laid;

m) whether weeding is done mechanically;

n) whether any other operation of maintaining or renewing the track is done mechanically. State which and the method employed.

Buenos Ayres Great Southern. — *a*) Hopper wagons.
g) In reservoirs suitably located.
h) Pneumatic tampers (as a trial).
i) No, because spikes are used.
m) By spraying with sodium chlorate by means of a « Magra » machine.

Buenos Ayres Western. — *a*) Hopper wagons.
d) Yes, locally.
e) With a crane in certain cases.
g) In new work and renewals, in a position adjacent to the work. For minor maintenance by hand.
h) Pneumatic packers with Ingersoll-Rand air compressor.
k) In important renewals, actuated by an oil engine.
m) Experimentally, by spraying with liquids and powdered substances.

Central Argentine. — *h*) Packing machines actuated by electric compressor.
k) Boring is done mechanically.

Cordoba Central. — *a*) Special wagons for unloading purposes.

Belgian National Ry. Co. — *a*) Wagons with low drop sides.
c) Scheuchzer machine.
d) Trollies and tractors.
g) In the shops before creosoting the sleepers.
h) With Collet electric generator sets (still only a limited number used).
i) Collet coach screwers.
j) By hand, using special spanners for renewals and maintenance repairs.
k) For boring.
l) Trials have been made by transporting up to 270 m. (885 feet) of assembled track. System abandoned on account of the difficulties encountered.

m) Chemically, with sodium chlorate. Special train for the spraying process.

Belgian National Light Ry. Co. — *i*) Electric coach screw drivers.
k) Electric boring machines.

Danish State. — *a*) Wagons with special devices for unloading.
d) Self-propelled trollies used experimentally.
f) Yes, as an experiment.
g) In the shops, before impregnation.
h) and *i*) In the renewal of the track.
j) By hand, in part with special spanners.
m) Mechanically with a machine hauled by a locomotive.

Madrid-Saragossa-Alicante. — *j*) By hand, with Robel spanners for new track and for renewals.
k) Hand boring appliances.

North of Spain. — *b*) Trials made with appliances operated by hand, for unloading; these are not in general use.
d) Trollies hand propelled.
g) Adzing and mechanical boring at places close to the work.
h) Collet packers.
i) Collet coach screwers.

Finnish State. — *a*) Automatic discharging wagons.
h) Pneumatic packers used experimentally.
j) By hand, in part with special spanners.
m) Mechanically with a machine which trims the ballast and weeds outside the sleepers. It is hauled by a locomotive.

French State. — *a*) Hopper wagons to discharge automatically.
c) Scheuchzer and Drouard screening machines.
d) Motor trollies for haulage.
g) In shops before creosoting.
h) In certain renewals, with Collet packers.
i) In renewals with Vignole rails. With Collet machines.
j) By hand. Ordinary spanners. Short at the start and long at the end of the operation.
k) Mechanical borers on certain occasions.
l) Placing the track in position by pairs of rails. Drouard and Collet systems.
m) Chemical weeding.

Paris-Ceinture Ry. — *a*) Hopper wagons.
d) Yes, exceptionally.
g) In the shops, without creosoting.
h) As a trial with pneumatic packers.
i) As a trial on mechanical maintenance work.
m) Chemically.
French Est. — *a*) Hopper wagons.
b) Bolster wagons fitted with a hand winch.
c) Scheuchzer screeners.

d) Loco-tractors for mechanised renewals. Motor trollies of 15, 20 and 40 H.P. hauling trailers for ordinary maintenance.

g) In the wood-working shops, before creosoting. Those which are usable after removal from the road, are collected, re-adzed with the Collet machine.

h) For mechanised renewals.

i) With Collet appliances.

j) By hand. In certain cases with ratchet spanners.

k) Portable workshop for cutting and drilling rails removed and re-used.

l) Yes, for track renewals with Collet appliances.

m) Chemically with sodium chlorate.

French Midi. — *d*) Motor trollies are used.

g) Yes, it is done on the works.

h) *i*) Yes, in mechanised maintenance trials with Collet machines.

m) Chemically with sodium chlorate.

Paris-Orléans. — *a*) Yes.

d) Yes.

g) Yes, generally in the shops.

h) Yes, with Krupp and Collet packers.

i) Yes, on the work with the Collet machine.

k) No, but mobile equipment for cutting rails concentrated at a convenient point is available.

m) Chemically.

Paris-Lyons-Mediterranean. — *a*) Self-discharging hopper wagons.

d) Trollies of 30 to 40 H.P. hauling trailer trucks.

g) In the shops before creosoting, and the reboring of the sleepers in the road.

h) Yes, with pneumatic and electric packers.

i) Yes, with electric coach screwers.

m) Chemically.

French Nord. — *a*) Wagons discharging from lateral hoppers.

b) Yes, by using special wagons.

c) Drouard and Scheuchzer screeners.

d) Trollies of 15, 20 and 40 H.P.

g) In the shops, before creosoting.

h) With Collet packers.

i) With Collet coach screwers.

j) By hand, special spanners.

l) According to the Drouard and Loiseau-Collet systems.

m) Chemically, with Occysol and sodium chlorate.

Bouches-du-Rhône Electric Rys. and Tramways (France). — *m*) Weeding, with a machine supplied by the « Société de désherbage et de piochage du ballast des voies ferrées » (Paris).

Algerian State. — *h*) Yes, with Ingersoll-Rand electric and pneumatic packers.

Prince Henry (Luxemburg). — *g*) Yes, in the creosoting depot.

m) In part with hand sprayers.

Netherlands Railways. — *b*) The trials have not produced any result.

g) Before creosoting.

h) Experimentally with pneumatic packers Their use has not been made general.

i) In the shops.

m) Mechanically with « Karlsson » machines and trials with chemical products.

Portuguese Railways. — *g*) Yes, in the shops before creosoting.

Swedish State and *Uppsala-Norrland (Sweden).* — *a*) Bogie hopper wagons.

b) With cranes mounted on flat wagons.

d) Twin-cylinder motor trollies of 5-6 H.P.

m) Mechanically.

Grängesberg - Oxelösund (Sweden). —

a) Wagons with drop sides.

m) Chemically with sodium chlorate.

Swiss Federal Rys. — *a*) Tip wagons of the Ochsner type, of 15 to 20 tons.

b) Trials with Robel and Niemag tools.

c) Scheuchzer screener.

d) Tractors of from 35 to 40 H.P. to haul trucks and trailers. Autocars for the conveyance of workmen.

f) With 4 to 6-ton rollers.

g) In the impregnating shops before creosoting.

h) With Krupp packers.

i) Yes, in the shops.

j) By hand, with Robel No. 8 spanner.

m) Chemical weed killing, and mechanically with the Scheuchzer weeding machine.

4. — Has the adoption of the foregoing mechanical methods given rise to the work being done better, to a greater speed of working or to a saving in the cost of the operations ?

Buenos Ayres Great Southern. — Results satisfactory with chemical weed killer using sodium chlorate (1 part by weight to 4 parts of water) 20 grammes of salt in solution for 89 metres to be treated.

Buenos Ayres Western. — The work is performed more rapidly. Mechanical packing is more regular and efficient.

Belgian National Ry. Co. — Greater perfection in adzing of sleepers, packing and weeding. Greater speed in coach screwing, boring and chemical weeding.

Madrid-Saragossa-Alicante. — Work performed rapidly.

North of Spain. — Adzing and boring of sleepers is more accurate. In general execution is more rapid.

Finnish State. — Good, quick, cheap work results. The packers have not given entire satisfaction.

French State. — Work satisfactory. With the screeners, better recuperation of the ballast than by hand. Greater rapidity.

Paris-Ceinture Ry. — Greater rapidity of execution. Mechanical packing more regular than by hand.

French Est. — In renewals, better finished and more rapidly executed work is obtained. (50 % of time is saved.)

French Midi. — Their use has not been made general as the operations for which power tools have an evident superiority (boring and coach screwing) play only a very small part in maintenance costs.

Paris-Orleans. — Better execution of the work, greater rapidity and in general reduced working costs.

Paris-Lyons-Mediterranean. — Its adoption depends on the nature of the work to be done. Seems particularly economical in the case of a track the foundation of which is not consolidated.

French Nord. — The mechanical work is quicker, leaves the road in better condition and it remains so for a longer period.

Grängesberg-Oxelösund (Sweden). — Mechanical weeding has not given satisfactory results. Chemical weeding gives better results on stone ballast than on gravel.

Swiss Federal Rys. — Work quicker and giving greater economy in the cost of the operations. Chemical weeding cheaper than mechanical.

5. — In all cases, please state the approximate cost as compared with that of the same operation done by hand.

Belgian National Ry. Co. — There is an economy in the use of machines, if they can be used sufficiently to compensate for depreciation and repairs.

Madrid-Saragossa-Alicante. — Cost price less than that for work done with ordinary tools. Tightening of bolts 0.0178 peseta with Robel spanner; 0.20 peseta with ordinary spanner. Boring, cost 0.037 peseta. With ordinary methods 0.166 peseta.

North of Spain. — Adzing and boring per sleeper: 0.28 peseta. Driving coach screws per linear metre of track: 0.28 peseta. Packing per linear metre of track: 0.70 peseta.

French State. — Approximate costs: Unloading of ballast: Ordinary wagon, 3.50 fr.; Hopper wagon, 0.50 fr.

Adzing of sleepers: by hand, 3.50 fr.; by machine, 1.75 fr..

Renewal of the track and ballast: by hand, 50 fr.; mechanically, 45 fr.

Paris-Ceinture Ry. — Only having been used experimentally, it was not possible to compare costs. It appears that used on a large scale it would be more economical.

French Est. — The economy has not been calculated but it exists.

French Midi. — The saving by mechanised maintenance is about 7.5 % of the total time.

Chemical weeding 0.05 fr. per application and per square metre (two applications annually). By hand, annual cost 0.30 fr.

Paris-Orleans. — The utilisation of mechanical appliances being recent, a comparison of working costs is not possible.

Paris-Lyons-Mediterranean. — The operations of packing, aligning and general tightening of the fastenings by means of electric packers and coach screwers cost 5.50 fr. per linear metre.

French Nord. — Is more economical, in the case of renewals on account of the greater daily output; in the case of maintenance, because it enables the periodical repairs to the track to be less frequent.

Swiss Federal Rys. — There is no information as to the economic advantages.

Part II. — Organisation of the work.

A. — Maintenance of the permanent way.

1. — What is the organisation which has been established on your railway for the maintenance of the permanent way by mechanical methods ?

a) Are the gangs in charge of the mechanical maintenance distributed uniformly along the line ?

b) Are the gangs employed concentrated at suitably selected points ?

c) In the latter case *b*) are the gangs uniformly distributed along the lines for examination, inspection and carrying out small maintenance jobs, retained ?

d) Are these last-mentioned uniformly distributed gangs the same as those in existence before mechanical maintenance methods were employed ? Have the

methods adopted enabled the staff to be reduced ?

Give details regarding this reduction and the staff composing the gang at the present time.

e) What is the number and type of the employees composing a gang for mechanical maintenance ?

Buenos Ayres Western. — Employs gangs for packing; it is the only operation in maintenance which is performed mechanically.
a) For the time being, only in the local sections.
b) Yes, in conformity with the programme fixed by the inspector responsible for upkeep.
c) These gangs are occupied only on maintenance. They are not concerned with supervision.
d) They have not justified a reduction in personnel but the standard of maintenance is improved.
e) The packing gang consists of a foreman, an assistant foreman and 18 men.

Central Argentine. — *d*) The gangs have been reduced.
e) 12 men and an assistant foreman with each machine.

Belgian National Ry. Co. — *Danish State Rys.* — *Madrid-Saragossa-Alicante.* — *North of Spain.* — Do not use mechanical appliances.

Finnish State. — Have no special organisation.
e) The ballast profiling machine, 4 or 5 men. Each packing machine, 2 men.

French State. — Does not use mechanised processes for track maintenance.

Paris-Ceinture. — Mechanised maintenance having been tried experimentally, the organisation of the gangs has not been altered.

French Est. — Does not use mechanised processes for track maintenance. Only trials on a small scale have been made on tightening coach screws.

French Midi. — Trials having been abandoned, there is no special organisation for mechanised maintenance.

Paris-Orleans. — A special organisation is under investigation, but it has not yet been adopted.

French Nord. — Has a special organisation for mechanised maintenance.
b) Makes use of centralised gangs.
c) and *d*) Makes use of gangs uniformly distributed along the line, but their strength has been reduced.
e) 10 men for repairs to fastenings and 13 for re-surfacing.

Paris-Lyons-Mediterranean. — Does not possess any special organisation.

Prince Henry (Luxemburg). — Has no special organisation.

Netherlands Railways. — Mechanised processes only having been tried experimentally, there is no special organisation.

Grängesberg-Oxelösund (Sweden). — The placing of ballast and weeding, the two only operations performed mechanically, are done by special gangs under the control of a permanent way foreman. This work is done in the summer.

Swiss Federal Rys. — Have not at present any special gangs organised for mechanical track maintenance. The maintenance work is done as a rule by the ordinary maintenance gangs.

2. — Are the gangs occupied on any work other than that of the maintenance of the permanent way ?

Buenos Ayres Western. — These gangs are engaged exclusively on maintenance.

Central Argentine. — No.

French Nord. — Do no work other than track maintenance.

3. — Do the gangs carry out the maintenance of sidings at stations and of track appliances, or only the maintenance of the running track ?

Buenos Ayres Western. — Only on main lines.

Central Argentine. — Only on running track.

French Nord. — Effect only maintenance on running lines.

Paris-Lyons-Mediterranean. — Do not use mechanised methods on sidings.

4. — What is the average length kept mechanically in repair by one gang on the main line ?

a) Are the roads in sidings included in this length ?

b) To what length of main line track corresponds a mile of road in sidings from the point of view of mechanical maintenance ?

c) In the case where the maintenance and laying of points, crossings, etc. is

done mechanically, to what length of main line track are these appliances equivalent ?

Buenos Ayres Western. — About 12 km. of quadruple track or 25 km. of double track.

a) and *b*) They are not used for secondary lines.

c) Is not done mechanically.

Central Argentine. — 22 km. of track.

a) No.

5. — Is the number of workmen in a gang for mechanical maintenance constant throughout the year or is this gang composed of a restricted number of permanent workmen, supplemented by temporarily engaged workmen ?

At what time of the year is the effective strength increased ?

Buenos Ayres Western. — Constant.

Central Argentine. — Yes.

French Nord. — The gangs are formed of members of the old gangs supplemented with casual workers from outside the railway, if necessary.

Paris-Lyons-Mediterranean. — There are no special gangs using mechanical plant exclusively.

6. — Do the gangs for mechanical maintenance carry out their work on the system of a general periodical inspection or as the result of special examination ?

In the first case, how often is a general inspection made ?

Buenos Ayres Western. — As found necessary, under the inspection of the assistant engineer or of the inspector.

French Nord. — Effects the work by periodical overhauls. The time elapsing between two overhauls will increase as the result of the adoption of mechanised processes.

7. — Please describe the order in which the work is carried out by the permanent way mechanical maintenance gangs, detailing the work done by mechanical methods and that done by the ordinary methods.

Buenos Ayres Western. — Mechanically only packing.

Finnish State. — The ballast profiling machine operates once yearly on all lines.

French Nord. — By 3 independent gangs; 1. Repairs to fastenings; 2. Renewal of sleepers; 3. Checking levelling. The second operation is done by hand.

Paris-Lyons-Mediterranean. — Mechanically, packing and driving coach screws.

8. — What is the length of the working day of these gangs ? Is it the same as in the ordinary gangs ?

Buenos Ayres Western. — 8 hours. — Yes.

Central Argentine. — 8 hours nominal. Yes.

Finnish State. — 8 hours.

French Nord. — The same as for the ordinary gangs.

Paris-Lyons-Mediterranean. — The same as for the personnel of the manual gangs.

9. — Are tables or graphs compiled showing the progress of work of each gang ?

In what form are these documents compiled ?

Buenos Ayres Western. — Yes.

Central Argentine. — Yes.

French Nord. — Each gang draws up a daily report. The areas send a summary of the work for each section and gang.

Paris-Lyons-Mediterranean. — In a very simple form in order to avoid clerical work on the part of the gangs.

10. — Has the cost of each of the following kinds of work been determined by means of direct observations ?

a) renewing one metre of track;

b) packing one sleeper;

c) renewing one sleeper;

d) renewing one cubic metre of ballast;

e) weeding one metre of track;

f) general inspection of one metre of permanent way;

g) renewing one metre of permanent way.

Finnish State. — No comparisons are made between the costs of manual and mechanical work.

Paris-Ceinture. — The trials made, of short duration, have not permitted of observations as to cost being made.

Paris-Orleans. — *g*) 21 fr. per linear metre, including the transport of materials.

French Nord. — The wages cost of the work only has been evaluated for each gang.

Overhaul of fastenings for 1 km. of track: 22.48 wage-units. Lifting of 1 km. of track: Mechanically 60.99 wage-units; by measured shovel packing: 37.17 wage-units.

Paris-Lyons-Mediterranean. — The costs cannot be determined definitely as they vary greatly according to the circumstances.

Grängesberg-Oxelösund(Sweden). — *e*) 0.07 Swedish crown per metre.

11. — Has the time lost due to the passage of trains or to other causes been taken into consideration?

Central Argentine. — Yes.

Paris-Ceinture. — The prices paid included all losses of time.

French Nord. — Without reckoning losses due to the passage of trains or other causes, since their costs are deducted from the effective work.

Paris-Lyons-Mediterranean. — Difficult to determine.

12. — How are the men composing the mechanical maintenance gangs, selected?

What are the qualifications or grade of the employee in charge of the gang?

Buenos Ayres Western. — No special selection is made.

Central Argentine. — The most experienced men are chosen. The foreman is chosen from the gangers.

Paris-Lyons-Mediterranean. — The chief gangers are the only ones to be selected from among those who already have some experience.

13. — Is this work carried out by the Company's own staff or by contract?

Buenos Ayres Western. — By the Company's own men.

Central Argentine. — By the Company's own men.

Finnish State. — By the Company's own men.

Paris-Ceinture. — By contract.

Paris-Orleans. — In general, by contract. There are two gangs of the Company for lifting.

French Nord. — By the Company's own men and with its own plant.

Paris-Lyons-Mediterranean. — By contract and departmentally.

14. — In the latter case, please explain how the inspection or supervision necessary to see that the work is done in a proper manner is effected.

Paris-Ceinture. — By the divisional and district foremen.

Paris-Orleans. — In addition to supervision, the contractor is responsible for maintenance during a certain period after finishing the work.

Paris-Lyons-Mediterranean. — In addition to supervision by the Company, the maintenance of the work for three months has to be guaranteed.

B. — **Renewing the permanent way.**

1. — What is the organisation employed on your railway for the renewal of the permanent way by the mechanical methods?

a) Is this work done by the same gangs as those in charge of the maintenance, with suitable reinforcements? In this case, what is the constitution of these gangs?

b) Are special gangs provided, intended solely for this work and having headquarters which are moved according to the section of permanent way to be renewed?

If so, state their composition.

c) In both cases, please state whether the effective strength of the gangs employed, when the renewal was not done mechanically, have been retained, or whether the number of employees engaged has been reduced.

Buenos Ayres Great Southern. — Does not use mechanised processes for the maintenance of the track.

Buenos Ayres Western. — Effects track renewal by mechanical methods.

a) Does not use maintenance gangs for this purpose.

b) Uses special flying gangs which live in encampments.

c) The strength of the gangs has not been reduced.

Central Argentine and Cordoba Central. — Do not use mechanised processes for the maintenance of the track.

Belgian National Ry. Co. — Does not possess any special organisation.

a) Does not use maintenance gangs for this purpose.

Utilises (when work is done by direct labour) gangs formed of casual workers and a few regular members of the local gangs or adjacent gangs. The casual workers are recruited locally.

Danish State. — Temporary gangs.

a) and b) They include a regular foreman and his assistant, several regular men from the local gangs and casual workers from the district when work is in hand.

c) The use of mechanised processes permits of a reduction in the number of workmen.

Madrid-Saragossa-Alicante. — Does not use mechanised processes for renewals.

North of Spain. — Possesses no special organisation; renewal by mechanical means is done by contract.

Finnish State. — Mechanised processes have not been applied to track renewals.

French State. — Done by specialist contractors.

Paris-Ceinture. — Have not yet applied mechanised methods for track renewals.

French Est. — Let by contract, the contractor supplying the mechanical plant.

French Nord. — By contract, by the Drouard an the Collet methods. Has a plan in view for using direct labour in centralised gangs, for replacing the rails only.

Paris-Orleans Railway. — This work has been up to the present only carried out exceptionally and then by contract.

Paris-Lyons-Mediterranean. — Mechanical renewal has been carried out by contract.

Bouches-du-Rhône Rys. and Electr. Tramways. — Do not use power plant except for weeding.

Algerian State. — Mechanised renewal has been employed of late but solely by a contractor.

Prince Henry (Luxemburg) and *Netherlands Rys.* — Do not use mechanised processes for renewals.

Portuguese Railways. — Swedish State. — Uppsala-Norrland (Sweden) and Grängesberg-Oxelösund (Sweden). — Do not use mechanised processes.

Swiss Federal Rys. — Do not possess any gangs solely used on track renewal by mechanised processes. The latter is generally placed in the hands of contractors.

2. — What is the average length of permanent way renewed mechanically by one gang ?

a) Are the tracks in sidings situated on the line included in this length ?

b) In this calculation, to what length of main line track does a kilometre of siding correspond ?

c) In the case in which the points, crossings, etc., are renewed mechanically, to what length of main line track is this work equivalent ?

Buenos Ayres Western. — About 400 metres nightly in 4 hours.

a) Mechanical methods are applied only to the renewal of running track.

Danish State. — About 120 metres daily.

Work in stations is done by special groups.

North of Spain. — From 35 to 40 pairs of rails 12.40 m. in length, making 400 to 500 m. daily.

a) and c) In the stations the running track only is renewed, excluding appliances.

French State. — From 500 to 1 000 metres of single line in 24 hours.

a), b) and c) The renewal of station roads and track appliances is carried out by hand.

French Est. — The average length renewed has been 600 metres daily in 10 hours of work.

French Nord. — Average length renewed : 600 metres in 8 hours of work. Is applicable only to running track.

3. — Please describe the order in which the work is carried out by the gangs during the mechanical renewal of the permainent way, specifying the work done by mechanical methods and, if the case arises, that which is done by the ordinary methods.

Buenos Ayres Western. — The track is laid by pairs of pre-assembled rails, 12 metres in length, by means of cranes. The old track is also likewise removed by pairs of rails. The assembling of the pairs of rails is done by hand in the depots.

Belgian National Ry. Co. — In renewals by contract, the driving of coach screws, packing

and boring, are performed mechanically. The use of mechanical plant is rare in work carried by the Company's own staff.

Danish State. — Packing and coach screwing is done by mechanical means.

North of Spain. — The road is assembled at the site. The operations performed mechanically are: Adzing and boring of sleepers, coach screwing, packing.

French State. — The track is placed by pairs of rails pre-assembled by the Drouard and the Collet methods.

French Est. — The track is placed by pairs of rails, pre-assembled in the shops, by the Collet system.

French Nord. — Mechanical renewal has been done up to the present by placing the track in pairs of rails pre-assembled in the shops. The Drouard and the Collet systems are used. A scheme is in hand for effecting the replacement of the rails alone, by means of Collet plant, by putting the new rails on the same sleepers as the old rails.

Swiss Federal. — The materials are distributed along the line. In the case of double-track lines, that to be renewed is put out of service.

Following performed mechanically: ballast screening; consolidation of the lower layer; unloading ballast, and packing.

4. — What is the length of the working day in these gangs? Is it the same as for the ordinary gangs?

Buenos Ayres Western. — The hours worked per day are the same as for the other gangs.

Belgian National Ry. Co. — The working day, as for the other gangs, is 8 hours.

Danish State. — The working day is 8 hours. The ordinary gangs work 9 hours in summer, the extra hour being compensated for in winter.

North of Spain. — The day's work is of 10 hours duration, of which two are paid as overtime.

French State. — That which is permitted by the period during which the passage of trains is prohibited — 10 hours — although this period may not have been fully utilised on account of the regulations on the legal working day and the distance away of the men's lodgings.

French Nord. — The normal duration of the working day is 8 hours. In some cases 6 hours, to conform with the periods during which traffic is stopped.

Swiss Federal Rys. — The length of the working day is 8½ hours in summer and 7½ hours in winter. The average legal length is 8 hours.

5. — Are tables or graphs compiled showing the progress of work in these gangs?

If so, please state in what form these documents are drawn up.

Buenos Ayres Western. — Do not keep either statements or graphical records of the progress of work.

Belgian National Ry. Co. — Statements shewing the progress of the work are used.

Danish State. — The statements and graphs shewing progress which are established are of a very simple nature.

North of Spain. — Graphs are kept on which are marked the materials stacked and the sections on which the renewal is effected.

Swiss Federal Rs. — Do not draw up graphs or tables, even when special observations have to be made on the work executed.

6. — Has the cost of each of the following kinds of work been determined by means of direct observation:

a) Renewal of one metre of rail;

b) Packing one sleeper, indicating the type of packer employed;

c) Renewing one sleeper;

d) Renewing one cubic metre of ballast;

e) Renewing one metre of permanent way.

Buenos Ayres Great Southern. — Does not use mechanised processes for the renewal of the track.

Buenos Ayres Western. — Gives no particulars as to cost.

Central Argentine Ry. and *Cordoba Central Ry.* — Do not use mechanised processes for the renewal of the track.

Belgian National Ry. Co. — Yes; in terms of the time [1].

a) 45 to 50 minutes.

b) 250 to 350 sleepers per day of 8 hours with two Collet packers.

c) 1 to 2 hours.

d) 4 to 8 hours. In 80 % of the cases, from 4 to 5 hours.

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[1] Although it is not stated, we assume that the figures refer to a working day of 8 hours.

e) 7 to 12 hours (including ballast).

Madrid-Saragossa-Alicante. — Does not apply mechanised processes to renewals.

North of Spain. — The contract price is 6 pesetas per linear metre, inclusive of the distribution and removal of material as well as maintenance for two months.

Finnish State. — Has not applied mechanised processes to the renewal of the track.

French State. — The work by contract is performed at a price per linear metre fixed in advance, including all the various operations.

Paris-Ceinture. — Has not yet introduced mechanised processes for track renewal.

French Nord. — In the contracts, unit prices are fixed for the different operations of the renewal work; these are liable to variation according to the traffic on the line. Sometimes also inclusive prices per linear metre of track renewed are fixed; these are liable to be amended if the amount to be done varies from that anticipated.

Bouches-du-Rhône Rys. and Electr. Tramways. — Do not use mechanised processes except for weeding.

Algerian State. — Mechanical renewal has only been tried quite recently and then by contract.

Prince Henry (Luxemburg) and *Netherlands Rys.* — Do not use mechanised processes for renewals.

Portuguese Rys. — *Swedish State Rys.* — *Uppsala Norrland Ry. (Sweden).* — *Grängesberg-Oxelösund Ry.* — Do not use mechanised processes.

Swiss Federal Rys. — Renewal is carried out by contract. The price per linear metre of permanent way including the ballast is from 11 to 14 frs.

7. — Has the time lost due to the passage of trains or to other causes been taken into consideration ?

Belgian National Ry. Co. — Are deduced from experience and note has been taken of the accessory duties of the personnel (look-out, piloting ballast trains, etc.).

North of Spain. — In the price indicated are comprised all losses of time.

French Nord. — In these rates all losses of time have been accounted for.

Swiss Federal Rys. — In fixing the price of the contract account is taken of the amount of traffic if the road to be renewed remains in service during the work.

8. — How are the men composing the mechanical renewal gangs selected ?

What are the qualifications or grade of the employee in charge of the gang ?

Buenos Ayres Western. — With the exception of the foreman and his assistant, all the men are temporary. The foreman is a 1st class regular ganger.

Belgian National Ry. Co. — The selection of the personnel is limited to regular men and specialised staff for the machines. The latter ought to have mechanical and, if possible, electrical knowledge.

Danish State. — Among the ordinary maintenance gangs.

North of Spain. — The personnel belongs in its entirety to the contractors; no particular technical knowledge is expected.

French Nord. — For the works by Company's labour the centralised gangs are formed of regular platelayers, in the same manner as for the maintenance gangs.

9. — Is this work carried out by the Company's own staff or by contract ?

Buenos Ayres Western. — The work in general is done by the Company. In the case of distant sections it is let to contract.

Belgian National Ry. Co. — Renewal is done by direct labour; by contract in regions where labour is scarce.

Danish State. — Perform the work with the Company's own resources, without recourse to contractors.

North of Spain. — The work has been done up to the present exclusively by contract.

French State. — By contracting firms which possess all the necessary plant.

French Est. — The work is done by contract.

French Nord. — Renewals following the Drouard and the Loiseau-Collet methods by contract. Proposals have been made for effecting them by direct labour, but following another method.

Paris-Orleans. — The work has been performed by contract.

Paris-Lyons-Mediterranean. — By contract, the Company being able to prohibit the use of machines if it perceives that the results are not favourable.

Swiss Federal Rys. — The renewals are done by contractors.

10. — In the latter case, please explain how the inspection or supervision, necessary to see that the work is done in a proper manner, is effected.

Buenos Ayres Western. — Inspection is done by the sectional engineer, an assistant and the inspector of the district in which the renewal is proceeding.

Belgian National Ry. Co. — Inspection and supervision is exercised by the technical inspector of the zone, assisted by his sectional foremen and regular workmen.

For important contracts, supervision on the spot is carried out by a sectional foreman, in other cases by a regular workman.

North of Spain. — The supervision of the work on the site is undertaken by two gangers. Inspection is exercised by the district foreman, the sectional foreman and the engineer of the area where the works are being executed.

French State. — Supervision, by a permanent way supervisor assisted by several regular workmen. The control of the works is entrusted to the district foreman concerned, aided by a leading hand. Inspection is assured by the sectional foreman and the inspector attached to the area foreman.

French Nord. — Inspection of the work is entrusted to a district foreman detached for duty on the work and assisted by inspectors in charge of the early operations.

Paris-Orleans. — Besides a constant supervision of the works by the Company, the contractor is responsible for the maintenance of the new road during a certain period.

Paris-Lyons-Mediterranean. — The execution of the work is supervised and the packing of all sleepers is checked by striking them. The contractor undertakes maintenance for three months as guarantee.

Swiss Federal Rys. — Detail instructions are issued relative to the execution of the works. Inspection is exercised on a permanent scale by the foreman of the district or his assistant; periodically by the permanent way engineer.

[625. 162 & 656. 254]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XIIth SESSION (CAIRO, 1933).

QUESTION I :

The protection of level crossings in view of modern developments in road traffic.

REPORT No. 2

(Belgium, Spain, France, Italy, Holland, Portugal and their Colonies; Denmark, Finland, Luxemburg, Norway, Sweden and Switzerland),

By Mr. BATICLE,

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The question of the protection of level crossings has already been considered by the International Railway Congress Association and many reports on this subject have been presented to it, in particular at Rome, in 1922, and at London, in 1925.

It has in fact become necessary to consider if the methods of protection employed since the introduction of railways, methods which at the present time still subsist in a great majority of cases, have not become out of date through the modern development of road traffic.

At previous Congresses the abolition of gates and the guarding of level crossings have been considered, as well as their replacement by warning signals or notice boards. The experience available was not however sufficient and it was decided to defer the investigation to a later Congress.

For this reason we were appointed to report again on this question to the Cairo Congress, for the following countries : Belgium, Denmark, Spain, Finland, France, Italy Luxemburg, Norway, Holland, Portugal, Sweden and Switzerland.

In order to obtain information upon what had been done and what it was proposed to do, in the countries to which our enquiry extended, we prepared a questionnaire which was sent to the Administrations concerned. Out of 104 Administrations consulted, 67 or 64 % replied, but 45, that is 43 %, alone sent information that could be made use of. The replies so obtained are condensed in the following and an endeavour is made to draw useful information from them.

CHAPTER I.

Legal standing, nature and classification of level crossings.

Legal standing of level crossings.

We should, as a beginning, endeavour to ascertain in the different countries the regulations which give legal standing

to level crossings and determine the conditions under which they are installed and classified :

Belgium. — From the information received from the Belgian National Railway Company, there does not exist, in principle, any law or ministerial regulation concerning the classification and the method of working the different level crossings.

With regard to their original construction the specifications for the construction and operation of railways stipulate in article 7 that all level crossings should have « a level stretch extending on both sides of the railway for a length of at least 7 m. (26 ft. 3 in.) outside the outer rails ».

In accordance with this article 7 the Department of Public Works indicates the level crossings at which there should be provided a level crossing keeper's cottage, or hut or both.

In particular all level crossings situated on ordinary roads or main roads are provided with a keeper's cottage.

Denmark. — The Danish State Railways inform us that the legal standing, the nature and the classification of level crossings result from the law relating to railway construction which decides if the level crossings should be protected or not.

In addition, a regulation of the 11 July 1923 issued by the Ministry of Public Works prescribes the establishment of these level crossings at places where the railway and the road cross.

Finally the law No. 28 of the 1 February 1930 and the regulation of the 16 March 1931 fixed the rules for installing and erecting signals at unprotected level crossings.

Italy. — The Italian State Railways have sent us a list of the regulations. These are :

Law of the 20 March 1865, No. 2248 : Article 212, Article 316.

Royal decree of the 31 October 1873, No. 1687, approving the regulations relating to the policing, safety and regularity of operation of the railways.

Law of the 30 August 1906, No. 272, concerning the special arrangements to be made when establishing and operating railways.

Royal decree of the 9 January 1914, No. 730, modifying article 13 of the regulations relating to the policing, safety and regularity of operation of the railways, approved by the decree of 31 October 1873.

Law of the 23 July 1914, No. 742, giving the dispositions relative to the staff of the State Railways and to the alteration of the rates.

Law of the 27 November 1919, No. 2375.

Decree of the 7 November 1920, No. 1608, authorising the Administration of the State Railways to leave open, permanently and without any obligation of protecting, level crossings on main and secondary lines.

Royal decree of the 31 December 1923, No. 3043. Circulation on public roads and places.

Royal decree of the 4 September 1925, No. 1751. Regulations relating to unprotected level crossings.

Royal decree of the 2 December 1928, No. 3179. Regulations for the protection of public ways and concerning circulation thereon.

Spain. — The Andalusian Railways, the Central Aragon Railway, the Madrid-Saragossa and Alicante Railways, and the North of Spain Railways have answered the questionnaire.

The Royal ordinance of the 5 June 1862 regulates the supervision and working of level crossings.

The law relating to the policing of railways dated the 26 November 1877, article 8, provides that level crossings shall be kept shut and only opened for the passage of vehicles or pedestrians.

The Royal decree of the 26 February 1885 indicates the procedure to be followed when establishing level crossings as well as the number, the class and the form of supervision of such crossings, for lines in operation.

The Royal ordinance of the 18 October 1919 and that of the 17 October 1921, in which the 8-hour day is dealt with, indicates in general terms the way in which the level crossings shall be supervised.

The Royal decree of the 22 June 1928 sanctions a classification of level crossings, submitted by the railways, based upon the figures of circulation of the trains and of the road traffic. It authorises the Companies to abolish, as an exceptional measure, the supervision of certain classes and to replace it by a system of signals. This ordinance was completed by that of the 23 June 1928.

Finland. — The Finnish State Railways have sent us the following information :

The law of expropriation obliges the railway to construct and to maintain the crossings necessary to guarantee the continuity of the public circulation.

The ordinance of the Ministry of Communications, dated the 2 April 1929, contains the prescriptions relative to the warning signals and protective appliances at level crossings of railways and public roads.

The road law of the 3 May 1927 prescribes at level crossings the removal of trees as well as the suppression of all other obstacles hindering visibility from a distance of at least 50 m. (164 feet).

Luxemburg. — The Prince Henry Railway indicate that their regulation of the 14 December 1868 stipulates in article 10 that : « when the railway runs along or crosses on the level the trunk roads, local roads, railways, private roads, etc., the work carried out to both one and the other by the concessionnaires shall have as their object to maintain constantly for the different forms of communication, the facility and safety of the traffic. »

The law on the policing of railways of the 17 December 1859, article 4, indicates that : « everywhere where the railways cross roads on the level, gates shall be erected and kept closed according to the regulations. »

Finally the Ministerial decree of the 25 July 1871 requires the Administration of the Public Works Department to report upon the necessity for the level crossings and upon the possibility of replacing them either by underbridges or overbridges. It has also to indicate those which ought to be lighted and those which should be closed by means of swing gates.

Norway. — From the replies sent by the Norwegian State Railways the legal standing of level crossings in Norway results from the law of the 12 August 1848, article 2D, according to which : « those who desire to build railways shall undertake to establish and build the level crossings required to assure the communications from one to the other side of the railway. »

Holland. — The Netherlands Railways inform us that the law upon the working and the use of railways of the 9 April 1875, modified in 1926 stipulates that : each railway shall be fenced in in the manner prescribed by the Ministerial regulations except in the cases indicated in this regulation. It indicates moreover certain obligations as regards the construction of buildings, walls, fences, or the planting of trees or copses near level crossings.

The regulation for the working of railways of the 26 June 1913, modified in 1930, indicates that « gates on public level crossings are operated and looked after by an employee stationed near the level crossing. »

It specifies in addition the conditions under which this keeping is to be done and the way the gates are operated. Under certain conditions the operation of the gates from a distance is permitted but in this case a warning apparatus must make it possible for the keeper to signal the closing of the gates to the users of the road.

Portugal. — The Portuguese Railway Company advises us that the closing and keeping of level crossings are prescribed by article 2 of the Police regulations for the operation of railways, of the 11 April 1868.

The location of level crossings with or without keeper is decided in the schemes for the construction of the lines.

Finally, article 2 of the regulations of the 11 April 1868 is worded as follows: « The Companies shall have keepers at all points where they shall be needed for the service of level crossings. »

Sweden. — From the information supplied by the Administrations who answered the questionnaire (State Railways, Göteborg-Boras and Boras-Alfvesta Railway, Karlskrona-Växjo Railway, Norsholm-Westerwik-Hulstfred Railway, Oxelösund-Flen-Västmanlands Railway, Stockholm-Vesteras-Bergslagen Railway, and Uppsala-Norrland Railway), it appears that the regulations regarding the protection of level crossings are contained in the Royal decree No. 318 of the 23 May 1924, which stipulates that the level crossings shall be divided into two classes, one including the crossings of railways and public roads, as well as private roads open to public circulation, and the other including the crossings of railways and private roads not open to public traffic.

Switzerland. — The Federal Railways advise us that the federal law dealing with railways, of the 23 December 1872, lays down the following general regulation: « Everywhere where the public safety demands it the Company shall establish at its costs a gate sufficient to prevent all danger, and shall keep this gate constantly in good order. In a general manner the Company shall undertake at its costs all measures which at the present time or in the future shall be considered necessary for the public safety. »

The conditions of classification and operation of level crossings are the subject of the federal ordinance of the 7 May 1929.

France. — The regulations governing level crossings in France are based on article 4 of the law of the 15 July 1845 which lays down that : « All railways shall be fenced in on both sides and for the whole length of the track » and that « everywhere where railways cross roads on the level gates shall be set up and kept closed according to the regulations. »

An exception has been made to this rule by the law of the 26 March 1897, which gives the Minister of Public Works the right to dispense the railways from the obligation of installing gates at certain level crossings.

In virtue of article 15 of the decree of the 11 November 1917, special Ministerial decrees for each railway fix the general conditions of working that the various classes of crossings should fulfil, having regard to the intensity of the circulation of the trains and the traffic on the road. These decrees specify the method of working for each class, prescribing the method of keeping, the type of gate as well as the circumstances in which they shall be open or closed.

It is then a matter for the Prefect to decide, according to the actual situation (conditions of visibility, etc.), the classification of each level crossing in one of the regulation groups by decrees approved by the Minister.

* * *

Regulations affecting the users of level crossings.

We have also endeavoured to ascertain what are the principal measures taken with regard to the public and principally those which have been introduced recently with the object of greater safety.

Belgium. — The Royal decree of the 20 May 1895 lays down that no person

and no vehicle shall cross level crossings at the approach of trains and locomotives. In addition, at 50 m. (164 feet) from running trains, the drivers of teams or animals are required to take all necessary steps to control these and prevent them from reaching the railway.

The Royal decree of the 2 June 1928 completes the preceding one by laying down that the passing, climbing over or opening of closed level crossing gates is forbidden.

Finally the drivers of vehicles shall not pass over level crossings at a speed above 10 km. (6.2 miles) per hour.

Denmark. — The prescriptions relating to this question are contained in the regulations for public order and safety on State Railways.

Italy. — The Italian State Railways have posted notices to the public calling their attention to the fact that as the result of some recent legal arrangements, a certain number of level crossings have had the gates removed and that drivers of automobiles, on their own responsibility, should before running onto the railway take the greatest care in order to avoid colliding with a train. This same notice indicates the warning posts which call attention to the level crossings in question.

Spain. — No text has been drawn up so far, but the question is under consideration.

Finland. — The decree No. 23 of the 18 January 1929, on the circulation of motor vehicles, stipulates that at the crossing of roads and other public ways the speed shall be such that the driver can immediately stop his vehicle.

Luxemburg. — All protected level crossings are provided with a warning notice: « It is forbidden to trespass on the railway. »

Norway. — The law of the 7 September 1854, in article 11 states :

All persons not belonging to the service who without authority go on to the railways or its dependances, embankments or cuttings are liable to a fine. In the same way anyone who in the places mentioned above rides, drives a vehicle, or leads cattle is punishable by fine. Those who stop horses, vehicles or cattle on a level crossing are liable to fines. Whoever on his own initiative opens a gate or other means of closing a level crossing or uses a level crossing while the gates are closed is liable to a fine. A fine can be inflicted on those who, owning a private crossing, use this crossing 10 minutes before a train which according to the timetable sent him or a given signal, is due.

Holland. — The regulation for the working of railways of the 26 June 1913, modified in 1930, includes a paragraph forbidding anyone to approach a level crossing with a vehicle at a speed higher than 20 km. (12.4 miles) per hour between the warning signal and the level crossing.

The driver of an automobile, motor bicycle, etc., is obliged, when approaching a level crossing, if he is not certain that no train is approaching and that he can pass without danger, to run at such a speed that he can stop before running onto the crossing.

It is forbidden moreover to draw ploughs, harrows, or other similar implements, as well as timber or other heavy objects across level crossings.

During the 10 minutes which precede the time fixed for a train to pass, cattle must not be allowed to cross when the keeper objects.

Sweden. — No special regulations exist.

Switzerland. — The Federal ordinance of the 7 May 1929 lays down that road vehicles shall stop at a distance of at least 10 m. (32.8 feet) from closed level crossing gates, if it is a question of level crossings provided with gates or with optical or audible signals, and that the drivers shall assure themselves and under their own responsibility that no train is approaching in the case of level

crossings only protected by signals in the form of a cross.

In all cases the railway line should only be crossed at a walking pace and, when approaching level crossings, the speed should be suitably reduced and in good time.

France. — Article 77 of the decree of the 11 November 1917 stipulates that it is forbidden :

To enter onto, to circulate in or stand upon, without proper authorisation, enclosed lands or dependences of the railway not open to public circulation, to introduce therein any animal or to let be introduced therein those for which it is responsible, to cause to circulate or stand therein any vehicle not belonging to the service, to throw or place therein any materials or objects whatever;

To allow to stand on the parts of a public way occupied by a railway, carriages or animals unaccompagnied, to throw or place any materials or objects whatever, to cause vehicles foreign to the service to run along the track of the railway.

In addition as far as railways of local interest built on the public roads are concerned, article 79 of the same decree stipulates that :

Every pedestrian, horseman, cyclist, motorist, or driver of any vehicle hauled by any animal, at the approach of a coach or a train belonging to the railway, shall immediately leave the railway, and be far enough away from it to give free passage to the stock moving over it;

Every leader of herds or animals shall keep them clear of the railway at the approach of a train or carriage belonging to the service of the railway .

We point out that in many cases crossings with wicket gates for pedestrians are placed alongside protected level crossings. The law has laid down that the use of these wickets is at the risk and peril of the pedestrians.

* * *

Classification of level crossings into groups.

We asked the various railways to give information on the classification into groups of the level crossings on their railways. Every classification of this kind is based on 3 factors :

— railway traffic;

— road traffic;

— reciprocal visibility of the road and of the railway.

We have given most weight to these three points in the following study.

Belgium. — The Belgian National Railway Company itself divides its level crossings into the following 6 groups:

With keepers stationed thereat;
Controlled by a keeper some distance away;
With part-time keeper;
No keeper;
Private, no keeper;
Paths, no keeper.

When distinguishing between level crossings with keepers, and those without, account is taken of the three elements pointed out above.

In a general way the level crossings which have keepers are situated at the stations and are operated by the staff of these stations.

The level crossings upon which the road traffic is important on certain days or at certain seasons have keepers outside these periods as well as during them.

The visibility is evaluated by taking into account the distance between the outside rail of the arrival line of the train in question and the position of the road where the observer stands.

No special measure has been taken in regions subject to frequent fogs.

In the Lower Congo, a decree of the Governor General dated the 18 September 1928 has divided the level crossings into 2 groups :

Level crossing with keepers;
Level crossings without keepers.

The Lower Congo to Katanga Railway has made this classification more definite by distinguishing 3 classes of level crossings :

Level crossings with keepers and gates;
Level crossings without keepers nor gates;
Level crossings with gates, without keepers.

As regards level crossings with gates, without keepers, the gates are opened and closed by the road users at their own peril and risk.

The reciprocal visibility of the road and the railway is the only condition required to bring the level crossing into the groups of level crossings without keepers.

Denmark. — The level crossings of the Danish State Railways are classified into 2 groups : public and private ; the first having either keepers or not.

The classification of level crossings is fixed by an « inspection and expropriation committee », nominated at the moment the railway is built ; this committee is composed of representatives of the government and of the communes concerned.

The classification into public and private groups is made after taking into account the road circulation.

As regards the question of knowing if there should be a keeper or not, in the first instance account is taken of the fact whether the railway, by the law which authorised its construction, has to be fenced in or not, and in the second instance of the nature of the traffic of the railway: number of trains, speed, etc. For instance, all public level crossings of a railway over which the trains pass at a speed exceeding 70 km. (43.5 miles) per hour should have keepers.

As regards visibility this is only taken into account in the case of level crossings without keepers.

Italy. — The Italian State Railways themselves divide their level crossings into four groups :

Level crossings with a keeper stationed thereat and provided with gates;

Level crossings with a keeper stationed some distance away with gates operated from a cabin;

Level crossings with a keeper and closed gates operated by the users;

Level crossings which are open and without keepers.

In order to decide if a crossing ought to be provided with gates or not, account is taken of three factors : railway traffic, road traffic and the reciprocal visibility of the road and of the railway, and furthermore of the particular conditions as regards the position of the level crossing, such as its nearness to a station, which makes it possible to look after the crossing without too great cost.

The visibility at a level crossing is decided by the effective visibility of the railway in the different directions as recorded by an observer placed 2 m. (6 1/2 feet) from the nearest rail, on the two sides of the road.

In practice, in order to leave a level crossing open and without a keeper its visibility must be greater than that obtained by the following formula :

$$L = l \times \frac{V}{2}$$

in which V is the maximum speed of the trains in kilometres per hour, and l the width in metres of the level crossing, increased by the maximum length of the vehicles with their teams, which will normally use the crossing. The value of L is increased by 1/5th in cases in which the railway is down a gradient steeper than 1 in 20 towards the level crossing.

In certain cases the frequency of fogs is also taken into account.

Spain. — The classification is made

by the State, and as a rule includes 4 groups :

1. Level crossings kept by 3 keepers;

2. Level crossings kept by 2 keepers during the day and 1 by night;

3. Level crossings kept during the day by 1 keeper and with no keeper at night, as no night trains run over it;

4. Level crossings without keepers but with signals to warn the public.

In order to arrive at this classification the three factors which we have indicated are also taken into account.

As regards the railway traffic, not only is account taken of the number of trains and of engines which pass over the level crossing, but also of the particular conditions of the level crossing, such as its nearness to a station, if the crossing is in the shunting area of the station in question.

In order to arrive at the road traffic, account is taken chiefly of the kind and number of the vehicles circulating thereon.

The visibility of the railway from the road is a condition taken into account rather in order to decide whether to retain or not the keepers at the crossing, than for classifying the level crossing.

A level crossing is considered as having good visibility when an observer placed on the centre line of the road 5 m. (16.4 feet) from the nearest rail has an absolutely clear view of both sides of the line for a length of 500 m. (1 640 feet).

In regions in which fog is frequent, the only precaution taken consists in requiring the driver to whistle frequently.

Finland. — The Administration of the Finnish Railways has laid down regulations as to the keeping and protection of level crossings, taking into account local conditions.

There is no general rule.

Luxemburg — On the Prince Henry Railway there are three groups of level crossings :

important level crossings;
unimportant level crossings;
and level crossings without keepers.

The classification is decided by the railway. In order to arrive at it, account is taken of the traffic on the railway and on the road, and if need be of the visibility.

In time of fog, the day signals are replaced by night signals.

Norway. — There is no classification, but the level crossings are divided into public crossings and private crossings.

The private level crossings are provided with gates the closing of which is incumbent on the owner.

The public level crossings may or may not have keepers.

When gates or signals are installed at a public level crossing, the local traffic of the railway is taken into account as well as the saving that can be realised by altering the methods of keeping the gates, previously employed, or the system of closing the crossing formerly used. As a rule the automobile traffic on the road has been the reason for replacing the old methods by gates or light signals.

Portugal. — On the Portuguese State Railways, there are 6 groups of level crossings, the classification being made by the company and approved by the Government :

1. Level crossings with very heavy traffic day and night.

2. Level crossings with heavy traffic both by day and by night, but less intense than that of the previous class.

3. Level crossings with average traffic both by day and by night.

4. Level crossings with some traffic on lines with few trains.

5. Level crossings belonging to private parties.

6. Level crossings for pedestrians and those not included in the above groups owing to their small importance.

In order to prepare this classification, account is taken in addition to the intensity of the road traffic and of the railway traffic, of the particular conditions of the level crossing, such as its nearness to a station, the shunting in which will interrupt the traffic on the crossing.

On the Lourenço Marquès Railways, there are three types of level crossing :

— level crossings having gates and light and audible signals;

— level crossings with keepers, fitted with chains;

— level crossings without keepers.

In order to arrive at this classification, account is taken as much of the trains as of the profile of the line, of the traffic on the roads which is normally very small, and of the conditions of visibility of the line and of the road, the construction of level crossings on curves being avoided as much as possible.

Holland. — On the Netherlands Railways there are level crossings with and without keepers. The Minister decides, on the proposition of the railway, into which group a level crossing shall be put.

At a level crossing without a keeper, the visibility is considered in relation to the importance of the road. In a general way a visibility of 500 m. (1 640 feet) on either side of the road, at 20 m. (65.6 feet) from the level crossing is accepted. For light railways these figures are 350 m. (1 150 feet) and 12 m. (39 feet).

Sweden. — The level crossings are divided into two groups, one including the crossings between railways and public roads or private roads open to public traffic, and the other, crossings between the railways and private roads not open to the public.

The Swedish State Railways, if it is a question of a crossing with the State Railways, or the Bridges and Roads Department, if it is a question of crossings with private railways, decide if a road crossing a railway should belong to the first or the second of the above classes.

In preparing this classification only the nature and intensity of the road traffic is taken into account.

When it is a question of knowing if safety devices should be installed at level crossings of the 1st class, the following prescriptions should be noted :

Warning signals in the form of a St. Andrew's cross should be installed at each crossing of the railway and the road. If the visibility is not sufficiently good, in addition special safety devices should be installed, such as: gates closed when the train is passing, light signals with winking lights when the train is coming, and white lights, also winking, when the passage is clear to road vehicles, an audible signal being given when the train arrives.

Gates are chiefly used when the level crossing is near a station, shunting in which is likely to interrupt the traffic. The audible signal is only employed on roads little used and on those where the motor circulation is very small. In all other cases light signals are used.

The visibility on the railway is considered to be good when the users of the road at whatever point they may be on a distance of 25 m. (82 feet) measured from the nearest rail can see the train, either by day or by night, at a certain minimum distance from the crossing. If a single railway line crosses the road, this minimum distance in metres is obtained by multiplying by 6 the km.-hours indicating the maximum authorised speed of the railway. In the case of two or several railway lines, the minimum distance is increased by 5 % for

each metre of the distance included between the middle of the outer roads and measured along the centre line of the road.

For crossings of the second group, there are no special safety devices.

In the event of fog, the driver should whistle repeatedly beginning at the maximum distance from the crossing calculated as we have shown above.

Switzerland. — On the Swiss Federal Railways there is no classification.

The only distinction that is made is that between level crossings on cantonal roads, those on communal roads and those on private roads.

France. — We have already indicated that the groups of level crossings are fixed by various decrees for the different railways. These groups are 6 in number on the Midi and the State (formerly Ouest) Railways, 5 on the Nord, the Est and the Paris-Lyons-Mediterranean (P.L.M.), 4 on the Paris-Orleans and the State (old system). The classification of each level crossing into one or other of these classes is made by decree by the Prefect, and approved by the Minister of Public Works.

In a general way, the group to which a level crossing belongs solely depends on the road traffic, and they can be divided up in the following way :

1. Largely used crossings (1st class on all railways). The level crossing is looked after by the keeper and the gates on most railways are normally open and are closed at the approach of a train, at least by day.

The P.L.M. system, alone, lays down for these level crossings that the average road traffic must exceed 100 vehicles per 24 hours.

2. Level crossings with average use (2nd class for all railways, except the Paris-Orleans and the State [old system] which also classify such level crossings in the 1st class).

The level crossing has a keeper, generally a woman, who can look after her household duties whenever the service allows. According to the railways, the gates are either normally open or shut.

The P.L.M. Railway classifies in this group those on which the road traffic varies between 50 and 100 vehicles per 24 hours.

3. Little used crossings (3rd class on the Nord, Est, Midi, P. L. M. and State [old system]), 2nd class on the Orleans and State (former Ouest system).

The level crossing has a keeper and the gates are as a rule kept shut.

On the P. L. M. Railway, in this class are put level crossings where the average traffic is less than 50 vehicles per day.

4. Private crossings [4th class on the Nord, Est and P. L. M., 5th class on the Midi and State (old system), 3rd class on the Orleans and State (purchased Ouest system), 3rd class on the Orleans and State (old system)].

The level crossing is fitted with gates the operation of which is carried out by the owners at their own responsibility.

5. Wickets for pedestrians [5th class on the Nord, Est, and P. L. M.; 6th class on the Midi and State (purchased system), 4th class on the Orleans and State (old system)].

6. Intermittent crossings.

These level crossings are the 4th class on the Midi and State (purchased system); they can be placed in any particular group according to the road traffic in the case of the Est, Orleans, P. L. M. and State (old system); such crossings do not exist on the Nord.

For each group the decrees fix very precisely the conditions of keeping, lighting, etc., of the level crossings. They also indicate in which cases the distant control of the gates can be authorised.

These decrees however make provision for relaxations of the general con-

dition of keeping the crossings which depend upon the railway traffic.

In order to make it clear how these two factors : the road frequentation and the railway traffic are brought into account, whe show diagrammatically the classification of a level crossing on the State Railway (old system):

		Railway traffic.	
		Important.	Small (relaxed regulations).
Road traffic	Important (1st class).	Gates normally open and keepers on duty while open.	Gates normally open, and without keepers.
	Small (2nd class).	Gates normally *shut.*	Gates normally *open,* without keepers.

We should add that the classification of level crossings of new lines or alterations of classifications of level crossings on existing lines is done by the Administration as a result of an enquiry carried out by the two services concerned : Railway Inspection Service and Road Service. During this enquiry the other different factors which affect the matter are taken into consideration : situation of the crossing near a station, speed of the trains on the line, etc., and above all visibility on the railway.

In order to appreciate this latter element, the Minister of Public Works requires the railways to attach to their request for classification of level crossings, sketches showing the visibility prepared in the following way (fig. 1).

Starting from each point A of the centre line of the road, on a line parallel to the direction of the railway line at the actual level crossing and on both sides of point A the ordinates Aa and Aa_1, equal respectively to the lengths OP and OQ of the zones of the line on which a train from one and the other direction is visible from point A, are drawn down. On joining the corresponding points a — on the one side — and a_1 on the other, we get one or several curves C and C_1 representing for a road user the visibility of the railway line near the level crossing.

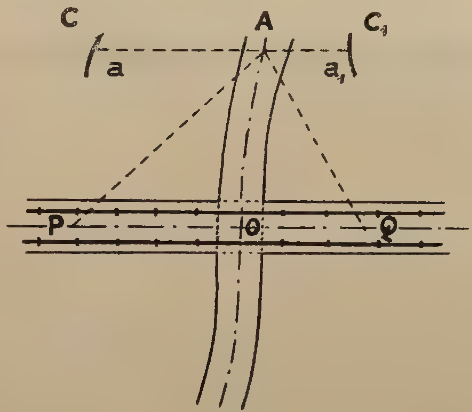

Fig. 1.

In this way sketches of the type of that shown in the present report (fig. 2) are obtained, sketches which make it possible, by simple examination, to ascertain the visibility at the level crossing considered.

We see therefore that the usual system of level crossings in France is that of crossings fitted with gates. There exist, however, level crossings not protected, the establishment of which is authorised by the law of the 26 March 1897. This

laws stipulates that the authorisation not to provide gates cannot be granted in the following cases :

1. on lines or sections of lines on which there are more than 3 trains per hour;

2. when running through densely populated centres;

3. in the neighbourhood of stations, halts and stops.

When a railway desires to remove the gates of a level crossings, it first of all

Fig. 2

Note : P. N. n° 7. = No. 7 level crossing. — Chemin vicinal ordinaire = Ordinary country road.

requests the authorisation of the principle of abolishing the gates at all the level crossings of the line or section of line considered. This authorisation is given by the Minister after enquiry by the Inspection Service; this enquiry considers solely the railway traffic of the line, the speed of its trains, its method of operation, etc. This authorisation of principle having been obtained the railway requests permission not to set up gates at each level crossing separately, and the enquiry carried out at this stage deals with the road frequentation, the visibility, the situation of the level crossing, etc. It is moreover carried out by the Railway Inspection Service and by the Road Service interested. If the two services agree, the decision is made by the Prefect; if they are not in agreement it is given by the Minister.

As from 1926, for trial purposes, the

gates of a certain number of level crossings not meeting these conditions have been abolished. We will indicate later on under what conditions these tests have been made and the results they have given.

Finally the frequency of fog in a region does not result in an alteration of the classification of a level crossing, but special safety measures have been ordered by the Ministerial decree of the 15 September 1910 :

In the event of heavy fog, when a train is due, the keeper shall not open the gates at the request of people in a carriage or automobile until they themselves have crossed the railway on foot. The driver shall then make the vehicle cross over.

The level crossings of the Alsace-Lorraine System are under a special regime. Those situated on the main lines are always provided with gates, those on secondary lines can be dispensed from the obligation of providing gates by the Supervising Authority, which is in fact the Prefect.

For the secondary railways these groups are also fixed by ministerial decree, and in each particular case the classification is decided upon by the Prefect.

In a general way 4 groups may be said to exist :

1. Public level crossings with keepers;
2. Public level crossings without keepers;
3. Public level crossings for pedestrians or cattle;
4. Private level crossings.

The factors taken into account in classifying level crossings into the different groups are those already indicated : road traffic, railway traffic, visibility.

As regards local railways, the classes are fixed by a decree of the Prefect, and in consequence vary from one Department to another. It should be added that in the case of these railways, most of the level crossings are not fitted with gates.

In Algeria (P. L. M. and State Railways) there are 5 groups of level crossings :

1. Crossings with keepers, where the gates are opened more than 100 times in 24 hours;
2. Crossings with keepers where the gates are opened from 50 to 100 times in 24 hours;
3. Crossings with keepers where the gates are opened less than 50 times in 24 hours;
4. Private crossings;
5. Crossings for pedestrians.

The classification is done in accordance with decisions taken by the Prefect, taking into account especially the road traffic.

In the other French Colonies the regulations governing level crossings are less precise, but it can be said that in general there exist two groups of level crossings : with keepers, provided with gates, and crossings without gates; the second of these is the most numerous.

CHAPTER II.

Protected level crossings.

We will consider the following points:

— Definition of the different methods of keeping crossings;
— Types of gate employed;
— Service of the crossing keepers;
— Announcing trains to the crossing keeper;
— Duties of the engine driver;
— Distant-operated level crossings;
— Signalling level crossings with keepers;
— Wicket gates for pedestrians.

Definition of the different methods of keeping crossings.

These are more or less the same on the different railways covered by our report. The gates are operated either at the site or from a distance.

When operated at the site, the work is done either by the keepers remaining constantly at the level crossing, or intermittently by keepers who are on duty at the times when the traffic is the heaviest, or by women who, when they are not required to be on duty, can carry out their household duties. At night the crossings are looked after by the keeper on duty, or the keeper goes to bed and comes and opens the gates whenever required by the public.

The distant-operated gates are worked by the station staff, the pointsman at a nearby station or the keeper of a nearby level crossing.

The system of working level crossing gates is : either normally open and closed at the approach of the train, or normally closed and opened at the request of the road users. At a given crossing according to the hour of the day, either system may be used.

Types of gate employed.

In the case of all the Administrations from whom we have received replies, lifting gates and rolling and swing gates are used chiefly. We should add that on certain lines with little traffic the simple chain is still in use.

The choice of the type of gate is regulated by local conditions; in particular, lifting gates are used when they are operated from a distance or when the level crossing can be interrupted fairly often by railway movements. This, however, is the kind of gate which appears at present to be the greatest success and certain Administrations, the Belgian National Railway Company for example, tend to replace all their swing or rolling gates by lifting gates.

Service of the level crossing keepers.

Belgium. — The level crossing keepers are either men or women; naturally men are used at level crossings where the circulation is important, and women at level crossings of average importance.

At night the service is always covered by men.

When male level crossing keepers are used they are selected from among the labourers and in preference among those no longer fit for their ordinary work, but none the less capable of looking after the level crossing with the necessary care for safety.

The women are the wives or daughters of men of the permanent way department, living in cottages built close to the level crossings.

The keepers are supervised either by the neigbouring station master or by the permanent way inspector.

The women keepers, who can look after their household duties in the intervals between trains, are on duty the whole time. The men are on duty 8, 10 or 12 hours if they live in the house at the level crossing. If they are not housed their turn of duty never exceeds 8 hours.

If the gates are interlocked with the signals, the keeper has to close these gates before the signal can be put to line clear. It is therefore only when the line has been asked for to allow a train to pass that the keeper closes his gates. In the case in which the gates are not interlocked with the signals, a local instruction determines at each level crossing the moment when the gates should be closed. If the visibility of the trains is very good the position is laid down at which the train has to be when the keeper closes the gates. If the visibility is not good the arrival of the trains is announced to the keeper by bell or by telephone, and at this moment he closes the gates.

Watches are not supplied to the keepers who have to provide them at their own cost.

The keepers must be constantly on the qui-vive; if they can see the trains coming a long way off, nothing hinders

them from allowing vehicles to pass even after the normal time of passing of the train if this latter is late. If they cannot see the trains coming they are advised by bell or telephone. In case these should be out of order, the keeper should call attention to the failure as soon as possible, and act with great care.

In time of fog the keeper should be more vigilant than ever and not let vehicles cross at the moment the train is expected.

The supervisory staff of the line advise him either by horn, bell or telephone when special or additional trains are expected.

Denmark — Men are employed at the most important level crossings; at the others women cover the service.

The keepers are recruited either as such or as assistants. There is no prescribed professional training; this is given them by their immediate superiors, who moreover are expected to supervise them. In the same way the drivers of the trains passing the level crossings should signal any irregularities that they observe whilst passing.

The maximum period of service broken by the intervals between the passing of trains is 12 hours, but if these interruptions are sufficiently important the time can be increased to 16 hours.

The keepers should close their gates as soon as a train approaches. If local circumstances : fog, snow or bad weather, hinder them from seeing the train at a proper distance they should close the gates five minutes before the train is due. They should themselves check the times the trains pass. For this purpose a watch is supplied to them by the administration.

The keepers receive information of unusual train movements by means of special signals carried by the preceding ordinary train.

Spain. — The various Administrations employ both men and women as keepers, men being used at the most frequent level crossings. As a general rule women are only employed for day service. These women are the wives of employees of the Company, or widows of employees or even the wives of cultivators living near the level crossing.

The keepers are not made to undergo any practical examination, unless it be a medical one. The North of Spain Railways however recruit their keepers from among the permanent way staff so that they may have a practical knowledge of the circulars, regulations, etc.

The supervision of the keepers is carried out by the permanent way inspectors who, during their turns of inspection, take note of any infringement of the regulations.

The hours of duty may be 16, on condition that the men have a continuous rest period of 8 hours, but in no case is so long a day required to be worked. In practice the average period of duty at a level crossing is 14 hours.

According to the Company, the level crossing be closed 5 or 10 minutes before the trains are due.

No watch or timepiece is supplied to the keepers, who have to procure one for themselves.

They get the correct hour from the permanent way gangers or from the maintenance men who, in going to their work, have passed a neigbouring station.

No provision is made for the case in which the train is late, According to the regulations the gates should remain closed, but in practice the keeper may open them after having satisfied himself by all means available that the train is not near the level crossing.

No special measures are laid down to deal with fog, which is very rare.

Exceptional train movements are announced, each time that this is possible, by the preceding trains, but in all cases the keeper should close his gates when he hears the noise of a train, and make

the necessary signals to stop the vehicles on the road.

Finland. — The keepers, men or women, are recruited among the permanent way men or the members of their families. They do not receive any professional instruction. They should understand the regulations and know the time the trains pass the level crossing. They are supervised by their superiors, but without the way this control is carried out being the object of any special regulations.

The women keepers have not the right during their turn of duty to look after their household. They must be constantly on duty all the time. The duration of service is generally 8 hours; however on lines with little traffic it may be longer.

The gates should be closed before the train arrives at the crossing, without any period being fixed for this closing. The keeper should provide himself with a watch and be sure that it keeps good time.

If the train is late, the keeper should take extra care and close his gates so as best to meet the conditions.

When fog or snow interfere with viibility, the keeper should observe the warning signals that the train under these circumstances has to give him. Exceptional train movements are, as far as possible announced by telephone or verbally.

Italy. — The keeping is done, according to the importance of the level crossing, either by women alone or by women during the day and men during the night, or by men alone.

The crossing keepers when men are recruited from among the permanent way men; the women from among their relations.

At the present time in certain cases the work is covered by private individuals with whom a special agreement is made after their physical and technical aptitudes have been ascertained.

Prior to appointed a keeper, a theoretical and practical examination has to be passed on the subjects with which he will have to deal during his service.

The crossing keepers are supervised by the permanent way staff.

The maximum period on duty of a male keeper is 9 hours a day, but it can be increased to 10 and even 12 hours. As regards the women, the turn of duty is 12 hours but it can be as much as 16 with intervals for rest.

The crossing should be closed 5 minutes before the time the train is due. For this purpose the railway system supplies the crossing keeper with a watch towards the price of which he contributes one fifth.

The permanent way supervisor should regulate by his watch those of the keepers he controls.

When a train is late the keeper is not usually authorised to open the gates to let road vehicles pass. However for certain level crossings at which the conditions of visibility are particularly good, he is autorised to allow such vehicles to pass when he is sure that the train is not in sight. This authorisation is also given in the case of level crossings connected by telephone to the neighbouring station.

In the case of fog the keeper should not open the level crossing when a train is expected.

Extraordinary train movements are as a rule announced by the previous train or by telephone. If this has not been possible the staff of the special train is warned that the permanent way service has not been warned of the running of the train in question.

Luxemburg. — Important level crossings are looked after by men; crossings where the service is not continuous are reserved for the wives of the men.

Male keepers are selected in prefer-

ence from the older men or among those who have been hurt in service.

The permanent way inspector is responsible for their instruction; as a rule the candidate for a level crossing post is attached for 8 days to a man already employed on this work.

The supervision is carried out by the permanent way inspectors.

The period of service may be 14 hours, or even in the case of men who are housed, 16 hours. No distinction is made in this question between men and women.

The gates should be closed 5 minutes before the booked time at which a regular train is due to pass.

The keepers have to provide themselves with a good watch at their own cost, which, if they so wish, can be supplied by the company's clothing store.

Officially these men are not given the exact time, but obtain it from the supervisors.

When a train is late, the keeper should redouble his vigilance and attention.

The gates once closed for the passage of a train cannot be opened until after the said train has passed.

In case of fog the gates are kept closed if there are no means of announcing the approach of a train to the keeper.

The keeper is warned of any special train movements by bell at the important level crossings, by signals given by the preceding regular trains, or by horn calls given by the keeper of the neighbouring level crossing.

Norway. — Women are prefered for keeping level crossings.

No special instruction is required of a woman keeper other than that she receives as an employee of the company.

There is no control outside the supervision exercised by the train staff.

Whether the keeper is a man or a woman the period of service is the same; neither is there any difference between the day service and the night service. The daily 24-hour service is divided between two people.

The gates should be closed 10 minutes before a train is due to pass.

The keeper should not leave his post after having closed the level crossing but on the other hand he gives the train the « line clear » signal. As soon as the train is passed, the crossing should be open to the road users.

The keeper has to have a watch which he has to purchase himself. When a train is late and he is on the telephone the nearest station should advise him of it, otherwise he does not receive any notice. He is advised of supplementary trains in the same way.

Holland. — According to the importance of the railway traffic, either a man or a woman is employed as level crossing keeper.

The keepers are usually permanent way men who are old or not fit for more active service.

There is no preliminary professional instruction and the keepers have to study the necessary regulations for themselves and carry out the service for a time under the supervision of an experienced keeper.

They are under the authority of the foreman who should supervise them although not in a systematic way.

Moreover, the drivers should report any fault they have observed.

The women are allowed to attend to their household duties.

The period of work is 12 hours for the keeper living near the level crossing, and 6 for the others. Women always live at the crossings in a house belonging to the railway. They cannot be on duty before 5 a. m. nor after 10 p. m.

The gates should be closed 3 minutes before the train is due, unless permission to alter this has been given to the level crossing.

The keeper should be in possession of

a watch properly regulated, for which he is responsible.

If the train is late and if the keeper has no means of being advised thereof, by telephone for example, he should keep the gates closed, unless, however, he has sufficient visibility of the railway.

In the case of fog, the measures are the same.

He is advised of any extraordinary train movements, either by signals carried by the preceding train, or by electric bell.

Portugal. — Male crossing keepers are employed for 1st class level crossings, and for some of the 2nd class; for the others women carry out the duties.

The men are platelayers, no longer fit for active service; the women keepers are selected in preference from the family of the maintenance staff.

In order to be appointed as level crossing keeper, a man has to undergo an examination and be passed as competent. In particular he has to be capable of being able to cover a distance of at least 1 000 m. (3 280 feet) in not more than 9 minutes, and to be able to distinguish at a distance of 1 000 m. (0.62 mile) the green and red colours of flags, to have a sufficient knowledge of the regulations for the policing and supervision of the track; the candidates are in addition subjected to medical examination.

The supervision of the crossing keepers falls upon the permanent way district foreman.

Women are allowed to attend to their household duties in the intervals between the trains.

The period of service consists of 8 to 12 hours, according to the group of the level crossing.

The gates should be closed 5 minutes before the trains are due.

In order to carry out their work, the keepers should provide themselves with a watch and the exact time is supplied to them by their superiors when making their inspection.

If the train is late the gates should be kept closed, except in the case of level crossings fitted with indicators.

In times of fog everything is done as during the night.

Extraordinary trains movements are announced by the preceding train.

Sweden. — The keeping of level crossings is chiefly carried out by women belonging to the family of the platelayers. However for level crossings where the service is heavy and for those operated from a distance, men are used.

No professional instruction is required of the men for this service. However the permanent way supervisor usually satisfies himself that the crossing keeper knows the requirements of the regulations for safety and that he knows how to apply them. This same employee must inspect the crossing keeper during his rounds.

The women can attend to their household duties.

The period of supervision is at the most 16 hours on end. The actual duration of service is counted as 20 minutes for each regular train plus a quarter of the period of supervision, this reduced by the time calculated for the passing of the trains. If T be the duration of supervision expressed in hours and t the number of trains passing during this period, the real turn of duty amounts to :

$$\frac{t}{3} + 1/4\left(T - \frac{t}{3}\right) = \frac{T+t}{4}.$$

The only regulation imposed on crossing keepers is that they shall take care that the closing of the level crossing shall not cause any of the trains to be stopped and the least possible stops to the road users.

They should have their own watch and the exact time is given them by the permanent way supervisor when he passes.

They can also ascertain it by telephone from the station known as the « Information station ».

According to what we have just said there is no special regulation for the cases of delayed trains, nor for foggy weather.

Special trains are indicated by telephone.

Switzerland. — Women are especially employed at level crossings, the men only being employed at crossings of great importance and at those which require uninterrupted night service.

The male crossing keepers are recruited above all among labourers no longer fit for the permanent way maintenance service. The inspectors are responsible for the instruction and examination of this staff, who undergo medical examinations as regards sight and bearing. The inspectors also supervise the crossing keepers during their rounds.

In a general way the women keepers can attend to their household duties. A rest of an 1 1/2 hours during which the service is, if need be, covered by a relief, should be granted in the middle of the day. The period of work is 9 hours out of 12 or 14 hours' presence.

The keeper should have a properly regulated watch; the exact time is given every morning by telephone.

The gates should be closed 3 minutes before the train is due. When 2 trains are due to cross a level crossing at an interval of 3 minutes at least, the gates should not be opened after the first train has passed. In the case of a delay of more than 10 minutes in the circulation of a train the station advises by telephone all the level crossings up to the next station.

The level crossing keepers are also advised by telephone of special train movements.

In case of fog, the locomotive staff and the crossing keepers are required to take extra care.

France. — The keeping of level crossings during the day time is covered :

either by a woman with broken turns of duty who can attend to her household duties when she is not required at the gates;

or by a keeper who is not allowed to leave the gates during his period of service.

Night work is always covered by men, under the following conditions :

either by the husband of the woman keeper, an employee of the company who gets up at the request of passers by;

or by a man on fixed duty.

The most economical system and that used by preference is that of the platelayer's house. It has the advantage of making it possible to house on the line a man of the permanent way staff and improve his condition. The men keepers are not employed except for level crossings with considerable road and rail traffic.

The period of service is 15 hours for the women when the night duty is covered by the husband, and 12 hours in all other cases.

The men keepers are recruited either from soldiers shown in the Official Journal for recruitment by preference or among men of the gangs who no longer have the necessary aptitude for the maintenance work but who are none the less capable of doing work in which their personal safety as well as the public safety is in question. It is necessary above all that they should have good sight, good hearing, and can open the level crossing quickly in the event of this being accidentally obstructed.

The women keepers are recruited as a rule among the wives of the men of the permanent way maintenance staff.

Before being made responsible for service, the keepers undergo an examination which makes it possible to ascertain their knowledge of the regulations. Moreover professional instruction is supervised by the local chiefs who fre-

quently examine them during their turns of inspection.

The supervision of the keepers is covered by their different chiefs. These latter should moreover make unexpected visits to the level crossings in order to ascertain how the keepers carry out their duties.

In principle the gates should be closed 5 minutes before a train is due, except in the case of the Alsace-Lorraine Railways, where the time is only 3 minutes. In practice this rule only applies to level crossings at which there is not a permanent keeper; in this latter case the keeper only closes the gates when the train is in view or when it is announced by bell.

In order to do their work the keepers should be in possession of a watch or a clock which they have to provide at their own cost, except on the Nord where it is supplied to them. The exact time is given to them by the men of all grades who pass the level crossing.

When they are asked to open the crossings while waiting for a train, delayed or not, the keeper should not open unless he is certain that the vehicle or vehicles have time to clear the level crossing before the train arrives. They should refuse to open, the gates if the train is in view within 2 km. (1.24 miles). At very much frequented level crossings, or where an accumulation of vehicles on both sides of the gates is to be feared in the case of considerable delay to a train, warning signals are fitted or the gates are interlocked with the permanent way signals.

We have already indicated that in the case of fog, when a train is expected, the keepers should not open the gates except when the occupants of the vehicle except the driver have got out and crossed the level crossing on foot.

Special train movements are reported to the keeper by signals carried on the preceding train. In addition the level crossings situated on the lines run over frequently by light engines are connected by telephone to the neighbouring stations.

Signalling trains to the level crossings.

Belgium. — Trains are signalled to most level crossings with keepers.

The appliances used are :

1. — Horn when the level crossings with keepers are close enough together.

2. — Bell without magneto if they are too far away to hear the sound of the horn.

3. — Telephone when it is a question of level crossings with many trains with back signalling of the trains from box to box.

Automatic appliances signalling the trains are not used.

Denmark. — At most level crossings with keepers there is a signalling system which acts when the train is due.

Spain. — On most of the railways there is no apparatus for signalling the trains. However the North of Spain Railway uses at some level crossings with keepers, near stations, magnetic warning bells which are actuated by the station when the stop signal is taken off.

Finland. — In some cases the departure of the train from the neighbouring station is signalled by bell or by telephone.

Italy. — Certain important level crossings are connected by telephone with the nearest station or have an apparatus for signalling trains which is operated by the neighbouring stations.

On certain lines with bell signalling, the approach of the train is signalled thereby.

Luxemburg. — On some lines an electric bell is actuated by the departure station of the train signalled.

Norway. — The crossing keepers are warned of the arrival of trains by telephone or by a special message.

Holland. — On the principal railways all level crossings receive advice of approaching trains.

On light railways there are only a few level crossings not so equipped.

This warning is given out by means of Siemens and Halske bells. These bells are worked by the stations by means of inductors 3 minutes before the departure or the passage of each train.

Automatic appliances are only used in exceptional cases.

The Siemens and Halske bells which are built and looked after with great care do not get out of order.

Portugal. — 160 level crossings with keepers are fitted with signals announcing the approach of trains.

140 of these are fitted with an alarm bell of the Postel-Vinay type, electromagnetically controlled by means of magnetos installed in the stations nearest to the level crossings.

Each time current is supplied by these magnetos the warning bell is struck one blow. According to a fixed code a certain number of rings of the bell corresponds to a given indication.

This system of signalling makes it possible not only to warn crossing keepers of the approach of a train but also of all the abnormal facts described in the signalling regulations.

The most serious drawback to this system lies in the fact that the bells are controlled by magnetos operated by the station staff, which often results in irregularities through the men responsible for transmitting the signals forgetting to operate the magnetos.

At other level crossings alarm signals are used of the « Trembleuse » type operated by batteries, the circuit of which is closed by the wheels of the train by means of bars of the Collas type placed close to the rails 5 km. (3.2 miles) before the level crossing.

The most frequent defect of this system is the breaking of the mercury control switch caused by the shock of the mercury on the tube of glass which contains it.

In spite of all this, however, the two systems have given good results.

Sweden. — The trains are signalled by telephone to all level crossings on the lines of the Göteborg-Boras and the Grängesberg - Oxelösund Railways. On these railways there are no automatic appliances.

The State Railways do not give any warning except to certain level crossings. They use for this purpose audible or optical signals which are operated either automatically by means of track circuits or more rarely by men at the neighbouring station.

These appliances give satisfaction and rarely get out of order.

Switzerland. — The trains are signalled usually from station to station by means of electric bells which give the different signals laid down according to the regulations for the working of trains.

Most of these electric bells have a clock movement with driving weights and are worked by the current from the departure station of the train signalled, by the local distribution system or by batteries.

The successive impulses of the current are given in a determined order, either by hand or by means of automatic transmitters.

The working of these appliances is satisfactory.

France. — The trains are not signalled except at certain level crossings with keepers selected by taking into account the conditions of visibility and of the road and railway traffic.

They have been dealt with in general programmes which have been approved by ministerial decree and are in course of completion.

The principle has been established of

giving all level crossings a warning whenever the duration of visibility is less than 20 seconds and when the product of the figures of the normal average traffic on the road by the number of trains in the direction considered is greater or equal to 600.

On the Alsace-Lorraine Railways however trains are signalled on the principal lines at all level crossings with keepers. This warning is only obligatory on secondary lines when the maximum speed allowed is equal to or over 40 km. (25 miles) per hour.

The automatic warning is realised in the following way :

On the Est Railway by indicator boards with electric bell distant operated either by bar transmitters or by track circuit.

In the old installations the indicator was released by the momentary passage of an electric current at the moment the wheels of the train came on to the appliance. In the recent installations it is obtained by breaking the electric current normally passing through the indicator.

On the P. L. M. system a Morse spring bar fixed close to the rail which actuates, when the wheels of the vehicle pass, the receiver situated at the keeper's lodge, this receiver consisting of a square signal with either white or red disc and by optical apparatus or bell.

On the Nord system an arrangement

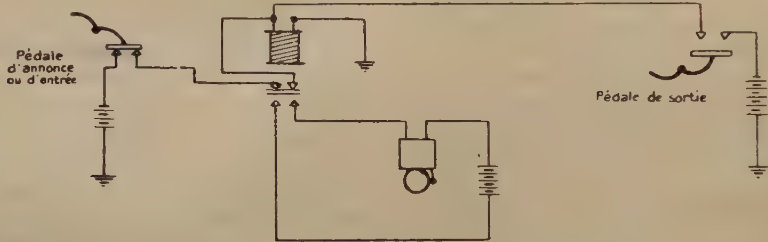

Fig. 3.

Explanation of French terms :

Pédale d'annonce ou d'entrée = « Warning » or « entrance » bar.
Pédale de sortie = « Release » bar.

is used similar to that we have described for the Est.

The State System uses a bar known as « entrance » or warning placed about 1 800 m. (1.12 miles) before the level crossing and which, when a train moves over it (fig. 3), de-energises a relay the armature of which short-circuits the contacts and causes a bell to ring until the train runs onto a second bar known as the « release » situated 50 m. (164 feet) beyond the level crossing, thus momentarily establishing a contact with the bar and sending the current of a battery into the relay. The relay thus re-energised remains hooked up with the leaving bar as a result of the entry bar returning to rest.

On a single line the installation is completed by a bar for preparing the warning bar situated about 500 m. (1 640 feet) in front of the warning bar and of a preparatory warning relay arranged in series, in order to avoid undesired signals which would persist after the trains had passed (fig. 4).

The Midi System uses disc indicator boards similar to those described above. The Alsace-Lorraine Railways use bells automatically operated by mercury switches.

All these railways state that the work-

ing of these various appliances is satisfactory.

When the trains are signalled by a station or by a neighbouring box, the advice is sent out on most of the railways by well-known devices such as the telephone, the Jousselin apparatus, the disc indicator, the disc being released by a press button or by working a lever in another box, by semaphore signal if the level crossing is operated from a block-system box, and by electric bells on single lines.

We should, however, call attention to

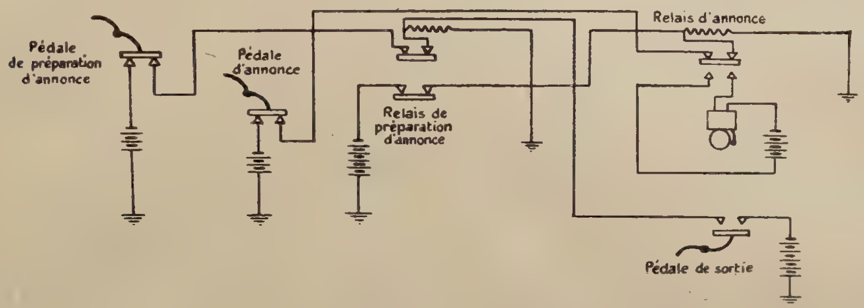

Fig. 4.

Explanation of French terms :

Pédale de préparation d'annonce = « Preparatory warning » bar. — Pédale d'annonce = « Warning » bar. — Relais de préparation d'annonce = « Preparatory warning » relay. — Relai d'annonce = « Warning » relay. — Pédale de sortie = « Release » relay.

the apparatus with reciprocal indicator discs used by the Midi. The level crossing is put into communication either with a station or with a signal box with 2 reciprocal indicator discs. The box or the station gives the order to close the gates by operating the indicator at the level crossing. The keeper reports that the gates are closed by opening the indicator of the box or of the station, and reciprocally.

Drivers' duties.

Belgium. — No action is required of drivers approaching level crossings which are moreover not signalled to them.

Denmark. — The drivers are not as a rule warned that they are approaching a level crossing and in this respect have no special duties to perform.

Spain. — At all level crossings according to the regulations there should be a sign « Whistle » but this rule does not appear to be kept except on the Andalusian Railways.

On the other railways the obligation of whistling is properly carried out by the driver without the place being marked by any « Whistle » board.

Finland. — At the approach of level crossings the drivers should signal their presence by whistling. Sometimes, however, when the visibility is bad, warning posts are used although they are not lighted at night.

The posts are placed alongside the line at a distance of visibility equal in metres to 4 times the maximum speed of the train in kilometres per hour.

Italy. — The drivers should whistle when approaching the most important level crossings. This obligation is not marked by any special signal.

Luxemburg. — The drivers also should whistle when approaching level crossings without however these latter being signalled to them.

Norway. — Before level crossings there is on the railway a special road crossing signal, passing which the driver uses his whistle; this signal is not lighted at night.

Holland. — No obligation is imposed on the driver when approaching level crossings.

Portugal. — The driver is not warned of the approach of a level crossing. He is expected to know the position of these crossings and whistle before reaching them.

Sweden. — At level crossings where there are keepers there is no regulation that the whistle is to be used.

Switzerland. — The drivers are under no obligation to whistle at level crossings as the position of these is not signalled to them; none the less they should take care to ascertain that the gates are closed.

France. — In accordance with the Ministerial decree of the 11 November 1917, modified by that of the 2 May 1930, the use of the whistle by the driver as a warning is obligatory when approaching certain level crossings to be named in a subsequent decree. This decree has not yet been promulgated and, while awaiting its issue, the use of the whistle is fixed by the regulations in force.

The level crossings so indicated will be signalled to the drivers by a board with the inscription « Whistle ». This board will not be illuminated at night.

Distant operated level crossing gates.

Belgium. — There are two methods of working distant operated level crossings :

— gates normally open and closed to allow trains to pass;

— gates normally closed and opened when requested by the level crossing users.

In general the level crossings must be perfectly visible to the employee who operates them, especially in the case of the first type.

In the case of the others, perfect visibility is not of capital importance when the road traffic over the crossing is small.

A bell with its pull conveniently placed for the users with a board beside it with the indication « Bell » is provided so that anyone can ask for the gates to be opened when necessary.

On his side the keeper warns the crossing users that the gates are to be closed by a bell which he operates immediately before and sometimes also whilst closing the gates.

As a general rule the users rarely complain of this system, which moreover is little used.

Denmark. — Distant operation of level crossings is done by means of wire transmission and in some cases by electricity. The keeper must necessarily have complete visibility of the space between the gates and the operating point which should not be further away than 800 m. (2 620 feet).

The road users also have permission to raise the gates. A bell gives warning of the closing of the gates.

This method of crossing keeping may give rise to criticism, especially as regards warning the users that the gates are about to be closed.

Spain. — Distant operation is little used in Spain and only at certain level crossings adjacent to stations, the gates being operated by the station staff or that of the signal boxes.

As a rule, the gates are normally open. Warning of their closing is given by a bell on the Madrid-Saragossa-Alicante Railway, but no warning at all is given on the North of Spain Railway.

On this latter, moreover, it should be noticed that in all cases the men responsible for working the gates have a perfect view of the approaches of the level crossing.

In no case have the road users any means of warning the employee working the gates that they want the gates opened.

Finland. — There are only a few distant controlled level crossings. They are operated either by hand or electrically.

Nothing is prescribed in the regulations as regards good visibility for the man operating them.

A warning of the closing of the gates is given by a bell which rings 18 to 25 seconds before the gates are closed. In addition, certain level crossings are fitted with lights which turn to red when the bell rings.

As a test, 3 level crossings have been fitted with systems working in conjunction with an insulated rail whereby, on the train arriving at a given distance from the level crossing, it warns the keeper and at the same time the warning bell rings until the gates are closed.

Tests have also been made with electrical arrangements with sound amplifying devices enabling the keeper to hear the whistling of the engine when the train approaches. These tests have so far given good results.

Italy. — Distant operated level crossings have their gates always open in the intervals between passing trains.

Good visibility for the operator is not required.

The crossing users have no means by which they can ask for the gates to be opened; nor would any such provision be of use as the gates are only closed when the trains are due.

A warning of the closing of the gates is given by a bell which rings shortly before the gates are operated.

The criticisms that can be formulated on this subject are the following :

1. Difficulty of regulating the operation and the possibility of something going wrong with the transmission;

2. Damage caused to the mechanism by the public when impatient to cross over;

3. Difficulty of giving audible warning signal of sufficient duration.

4. Difficulty of applying any control to the closing of the gates from the point of view of the railway;

5. Possibility that the gates may close too quickly;

6. Possibility when one of the gates closes before the other of shutting in crossing users between the gates.

Luxemburg. — The distant operated level crossing should be perfectly visible to the keeper. The latter before operating the gates rings a bell and makes sure that there is no vehicle on the track.

The road users can ask by means of a bell for the crossing gates to be opened.

Norway. — There are distant operated level crossings worked either by electric motor or by mechanical means.

It is not always possible to get satisfactory visibility conditions at these level crossings, as they are generally near stations, which are often built at places where the railway is on a curve.

No means of communication exists between the road users and the crossing keepers.

When the gates are about to be closed, the users are warned by means of a bell or horn at the same time as the light signal of the gates changes from white to red.

No criticism has been formulated. However this system is only satisfactory if the road users are careful, as there is danger for them of finding themselves shut in between the two gates.

It is for this reason that it is as well to leave between the gates and the rail-

way lines enough place for a vehicle to stand.

Holland. — Distant operated level crossing gates are normally open, but should be closed 3 minutes before the train is due. The level crossing should be visible to the keeper who operates the gates, but the same requirement is not obligatory as regards the immediate surroundings of the crossing.

There is no method of communication between the road users and the keeper.

A bell gives warning of the closing of the gates but as this bell is insufficient to warn motor cars, optical signals in the form of a red disc showing at night the word « Stop » have been introduced in recent years.

Portugal. — There are no distant operated level crossings.

Sweden. — Distant operated level crossings are worked either electrically or mechanically.

Perfect visibility is not an indispensable condition.

In the same way there is no special arrangement by which the road users can call the keeper's attention to their presence.

This method of working has been in use so generally and for such a long time that the road users are accustomed to it and raise no criticism.

Switzerland. — The visibility at distant operated level crossings should be good as the keepers are required to see that nobody is shut in between the gates.

No means of communication between the road users and the keeper is provided.

Moreover it is formally forbidden when closing distant operated gates to wait a short time before operating them, i. e. to give a warning signal and close the gates after a short interval. The gates should be closed, on the contrary, very quickly.

France. — The French railways have distant operated level crossings.

As a rule these level crossings are found on secondary lines. The State System has, however, a tendency to use such crossings on more important lines.

These level crossings may be either of the type with the gates normally open or with the gates normally shut.

The larger number however is of the latter kind.

The Administration in all cases requires the visibility to be very good, and especially so when the gates are normally open.

A bell is provided which the road users ring for the gates to be opened. Inversely, the keeper warns the users that the gates are to be closed by several rings of a bell. In certain cases this latter bell is operated before the gates are closed; in other cases it rings while the gates are closing.

A certain number of these level crossings are fitted with train signalling apparatus, the receivers being placed at the box from which the level crossing is operated.

On the P. L. M. System, for example, this signalling is compulsory :

1. when the length due to the difference between the distance of visibility from the signal box and that which separates the level crossing from the signal box is run over in less than 20 seconds by a train at the maximum speed authorised for the line;

2. when the signal box and the level crossing are not visible one from the other.

The distant operation of level crossings has the drawback that a vehicle may be closed in between the two gates without in certain cases the keeper being aware thereof. Nevertheless, thanks to the vigilance of the staff and the care taken by the users who know the level crossings in question, which are generally situated on farm roads and used most often by the same people, accidents under this head are very rare.

Distant operation tends to become general in France.

Signalling of level crossings with keepers.

Our enquiry related especially to the question of knowing if road users were made aware during the day and during the night of the presence of level crossings with keepers, if the gates were painted in any particular way or were fitted with reflectors or lights, if the gates were interlocked with the permanent way signals, and finally if these level crossings were indicated either by fixed signals or by signals announcing the approach of the trains.

Belgium. — Level crossings with keepers are indicated during the day by the advanced international signal : a triangle with a gate painted in white on a blue ground; at night by an orange notice placed in front of the lamps lighting up the level crossing.

These signals have so far been presented and maintained by an organisation outside the railway, which latter has simply erected them.

All level crossings which may be used during the night are lighted by 1, 2 or even 4 electric, gas or paraffin lights.

The gates are painted white as are the adjacent fences. Opaque square plates painted in white and red checks are placed on the panels of the rolling gates. They measure about 3 ft. 3 in. on each side, and the headlamps of automobiles light them up from a fairly considerable distance.

As regards lift gates, plates of the same kind but smaller are placed on the poles. The railway tends, in the case of this latter type of gate, to make general the installation of an electric or paraffin lamp placed at the centre of the gate, which shows a red light in the horizontal position and a white one when the top boom is vertical.

Most of the level crossings of any importance are interlocked with the adjacent signals. This practice gives greater safety to the public and although it makes it necessary to keep the gates closed longer than if no interlocking existed, this arrangement tends to be used increasingly.

There are no signals announcing the approach of trains at these level crossings.

The Lower-Congo to Katanga Railway Company calls attention to the presence of level crossings by white rectangular notice boards on which is written in black the words « Beware — Level Crossing ». This board is not illuminated at night.

Denmark. — The existence of the level crossing is indicated to the road users at least in the case of the most important roads by means of the international triangular signal. These signals are put up and maintained by the Automobile Associations.

Level crossings which are much used are lighted by a suitable number of white lights.

The gates are painted in red and white squares. They are not fitted with reflectors, but a lamp with three red lights is carried on a triangular plate. Some gates are in addition fitted with corrugated sheets in order to improve the distance from which these lights can be seen.

Spain. — In a general way, level crossings are indicated by means of sign posts, either of the international or of the older pattern. They are only very rarely illuminated at night.

The Andalusian Railways use on roads having considerable traffic a green light placed at a distance of 50 to 100 m. (164 to 328 feet) from the level crossing according to the profile of the road.

With the exception of the Central Aragon Railways, the railways paint the gates in a special way to improve the visibility. Thus, for example, the Ma-

drid-Saragossa-Alicante Railways use a system of painting in bands of white and black. The Andalusian Railways paint their gates in red and white; the North of Spain uses in certain cases reflectors which are placed practically the full height of the gate.

On none of the systems is the fact that the gate is closed indicated by a red light during the night.

The gates are only interlocked with the signals in very particular cases as for example round towns when the level crossing is used by tramways.

Signals indicating to the road users that a train is about to pass are not used.

Finland. — The road authorities set up warning signs in the form of a triangle in conformity with the International Convention.

The railway places a warning sign in the form of a Saint Andrew's cross, a single cross for a single line, a double cross for two or several lines, at a distance of 8 m. (26 feet) from the nearest rail, to the right of the road, facing the railway. This sign should be visible to road users at a distance of 15 m. (50 feet) at least if the circulation of motor vehicles over the crossing is forbidden, and at a distance of 50 m. (164 feet) in other cases.

If the conditions of visibility make it necessary, the signal can be placed either on the left of the road, or further from the railway without this distance exceeding 15 m., however; at much frequented level crossings these signals are fitted with lights, as for example with winking lights to make them more visible.

There are no special arrangements for illuminating the level crossings.

The gates are painted in black and red; they are indicated by night, when closed, by a red lamp. In some cases, as an experiment, reflectors have been fitted either on the gates or on the crossing signs. The gates are not interlocked with the permanent way signals.

Moreover signals announcing the approach of a train are not provided.

Italy. — Warning of protected level crossings are not given to road users, neither by day nor by night. There are no signals and the level crossings are not illuminated.

The visibility of the gates is increased by painting them in black and white or white and red stripes.

Reflectors are not used.

Certain level crossings have the gates interlocked with the permanent way signals. The keeper after having closed the gates can work these signals or advise the next signal box.

These arrangements are limited to a small number of level crossings and there is no tendency to multiply them owing to the annoyance they cause the public, as has been seen in practice.

The road users are not warned of the approach of trains at level crossings.

Luxemburg. — On the main roads the State puts up indicator posts. On other roadways no indication of the presence of level crossings is given.

At night level crossings are lighted by a lamp giving a white light carried on a post. The keeper has also his hand-lamp with which he gives a green light when a train is passing.

The visibility of the gates is increased by means of suitable painting : for rolling gates, black frame with white cross bars; for lift gates, uprights black and the bars white. The gate is not interlocked with the signals, but in the case of level crossings operated from the stations a notice has been put up in the signal boxes « Close the level crossing gates before taking off the signals ».

Norway. — The level crossings are signalled by St. Andrew's crosses placed at such a distance from the level crossing that vehicles of all kinds can stop before reaching the railway.

The level crossing are not as a rule illuminated except those in the neighbourhood of stations.

The gates are painted white and red; reflectors are not used.

Lifting gates are fitted with a lamp which gives, when the gate is closed, a red light, and when open, a white light.

Holland. — Protected level crossings are announced by the international signal erected about 200 m. (656 feet) from the level crossing, by the tourist and automobile clubs, who are also responsible for their maintenance.

Certain level crossings, indicated by the State, are illuminated. Until recently this lighting was by means of paraffin lamps placed between the gates; at the present time the paraffin lamps are being replaced by electric lights with reflectors placed on each side of the level crossing and illuminating the gates. The gates are painted white and red in bands 1 m. (3 ft. 3 3/8 in.) wide. They are fitted with reflectors with orange glasses 6 cm. (2 3/8 in.) in diameter placed 1 m. up.

In certain cases the gates are interlocked with the station signals when the station is near the level crossing. This arrangement has certain difficulties as regards the traffic. Consequently there is a tendency to suppress it.

The East Indies Railways signal their level crossings by means of triangular notices bordered red and showing in white a gate or a black ground. These signals, placed 150 m. (492 feet) from the level crossings, are erected and maintained by the Java Motor Club.

The gates are painted in black and white stripes.

Portugal. — The Automobile Club erects the international signal 250 m. (820 feet) on each side of each level crossing.

The level crossings are not illuminated at night.

The gates are painted in red with a white diagonal.

There is no sort of signalling for level crossings.

The gates are quite often interlocked with the permanent way signals, and this arrangement tends to increase.

It may be mentioned that the Administration of the Lourenço-Marquès Railways requires the keepers of level crossings to give the road users signals during the day with green and red flags and at night with lamps of the same colours. The gates are painted white.

Sweden. — Warning signals are not provided at level crossings with keepers. These crossings are not illuminated except in the towns or where the population is large.

The gates are painted in red and blue squares. They are not fitted with reflectors. When they are closed a red light is shown.

A certain number are interlocked with the permanent way signals and this arrangement tends to increase.

The road users are warned of the approach of trains by optical signals which automatically show a winking red light or by an automatically operated bell.

Switzerland. — Advance signals intended to warn the road traffic in conformity with the international convention are placed by the authorities responsible for the roads.

The level crossings are illuminated by an electric or a paraffin lamp giving a white light; the gates are painted in two colours : red and white in 1 metre wide bands.

On roads much used by automobiles a plate called the « Principal signal » consisting of an equilaterial triangle of 70-cm. [27 1/2 inches sides with a black edging of 7 cm. (2 3/4 inches) and a white light] is placed on both sides of the railway on the gates, on the centre line of the road. These boards are often

fitted with reflectors consisting of 15 red elements arranged on the black edging; sometimes a red light is also fitted on the white background.

France. — At many level crossings with keepers there are warning notices, which are set up either by the road services or by the tourist associations; there is therefore no fixed rule as regards the level crossings at which they should be provided, nor the conditions under which they should be erected. These signals as a rule are of the international type; sometimes however they display, instead of a gate, a locomotive. They are not illuminated at night.

The Alsace and Lorraine system erects at certain much frequented level crossings warning boards placed at the position at which vehicles and animals should be stopped when the gates are closed.

The illumination of level crossings is laid down in the Ministerial decree which classifies level crossings; it changes therefore from one system to another, but it can be said as a rule that according to the importance of the road traffic a level crossing is either illuminated by 1 or 2 white lights, or is not lighted at all. However, for reasons of safety the Government sometimes requires the railway to illuminate level crossings under conditions not provided for in the decree of classification.

As a result of the increase of automobile traffic the Alsace-Lorraine system before the war intended to improve the illumination of the most dangerous level crossings by placing special lamps with a double black cross on a white ground. The fitting of these luminous signs has been suspended.

All the railways improve the visibility of the gates by means of suitable painting. In certain cases the railway considers it sufficient to paint the upper part of the gate in white, but the most usual method is to paint this part in bands 1 metre wide alternately white and red. In addition rolling or swing gates are fitted with plates 1 metre square painted white with, in many cases, a red band arranged diagonally. In the case of lifting gates these boards are replaced by an arrangement of 7 articulated flat bars, painted alternately white and red. On the Alsace-Lorraine system the red is frequently replaced by blue.

The use of reflectors is becoming more and more general at much frequented crossings. They are attached to rectangular bars 5 to 10 per bar, according to size, the bars being secured to the gates 80 cm. (2 ft. 7 1/2 in.) above the ground. Each gate has 3, 4 or 5 bands according to the width of the level crossing.

At level crossings in large towns, where motor drivers should dim their headlights, the reflectors are replaced by one or two red lights given by electric or petrol lamps in which the light changes to white when the gate is open. Some railways also show the closing of the gates at level crossings of medium importance by a red light.

The interlocking of the gates with the permanent way signals is done in very special cases : it does not appear that the railways are likely to extend this practice.

Among the other systems of signalling used, the following may be mentioned :

The P. L. M. provides in certain cases at a few metres from the gates and outside the railway property lamps fitted with a special optical arrangement (converging lenses and spherical mirror) and focussed in such a way as to project the beam of light on the visibility board of the gate. Another side of the lamp shows a light visible from the road.

The State system will install in the near future an optical and audible arrangement on the lift gates of certain level crossings, chiefly those distant operated. This arrangement consists of

a moveable panel with the inscription « Stop » and a loud electric bell. These two devices are put into action when getting ready to close the gates, a few seconds before the closing actually begins.

On the secondary railways, light railways, and colonial railways, the arrangements adopted are very variable, but on the whole present no novelty on the methods of signalling used by the great railways.

Wicket gates for pedestrians.

The use of wickets is not permitted on the following railways :

— *Spain* (Madrid-Saragossa-Alicante Railways, Andalusian Railways, Central Aragon Railways);

— *Finland;*

— *Holland;*

— *Sweden* (Grängesberg - Oxelösund Railway);

— *Switzerland.*

There are a number in Belgium, principally at distant operated level crossings, the gates of which are normally closed and opened at the request of drivers of vehicles, in Italy, in Luxemburg, in Norway, in Portugal, in Denmark, in Spain (North of Spain) and in Switzerland (Federal Railways).

They are provided on the other hand, at the majority of crossings, in Sweden (Göteborg Railway) and especially in France.

In all the administrations where passages for pedestrians are used, these passages are crossed at the risk and peril of the users, the keeper not intervening unless he sees the pedestrian running into danger.

The most usual system for closing these crossings is a small gate which the pedestrian opens and which closes by itself.

In certain though rare cases, the turnstile is still used.

* * *

As can be seen from the above replies the safety arrangements put into use at level crossings with keepers have increased in number during recent years.

Consequently we have asked the different administrations if they could show us by figures and by facts that these arrangements have in fact given the results that were expected of them.

Most of the administrations have not been able to answer this question. They have informed us that it is difficult to come to any conclusion in view of the rapid increase of road traffic during the last few years.

The French Nord however has sent us an interesting reply which is reproduced hereafter.

Since 1921, 1 518 level crossings of this railway have been fitted with safety devices both as regards the keeper and the users of the level crossing, namely :

— 641 have been fitted with warning bells, gongs, repeater bells;

— 503 have had the gates fitted with signals, reflectors or red lights facing the road side;

— 374 have been fitted with both these classes of devices.

During this decade, the annual number of accidents at level crossings with keepers has fallen very appreciably : from 46 in 1921 to only 23 in 1930.

There has therefore been improvement and this improvement is the more appreciable seeing that during the same period the number of automobiles put into circulation in the departments served by the Nord system has increased from 90 000 to 383 000, so that while the number of automobiles has quadrupled that of the accidents has diminished by half, in other words the efforts made by the railway to improve safety at level crossings has contributed to

reduce in the proportion of 8 to 1 the percentage of accidents at crossings with keepers.

CHAPTER III.

Level crossings without keepers.

Our enquiry into level crossings without keepers dealt especially with the signalling of the said level crossings.

We asked the various administrations to give information as to the use of the international advance signal of the St. Andrew's cross type with one or several arms, of the signals warning road users of the approach of trains and on the results that have been obtained by the use of these different signals.

It should be noted first of all that taking the railways as a whole the number of level crossings without keepers is increasing.

Belgium. — The international signal is not obligatory, but it exists at the majority of level crossings without keepers situated on roads carrying vehicular traffic. It is in such cases erected 250 m. (820 feet) from the level crossing. It is followed in all cases by the position signal in the form of a St. Andrew's cross. It can be said, as a general rule, that the international signal is placed at level crossings used by an average of not less than 10 automobiles a day, and the St. Andrew's cross signal at all level crossings without keepers on roads carrying vehicular traffic.

The use of reflectors has been given up as these are hardly efficacious unless a very intense light falls on them and this is not always the case.

Where they are used the advance signals are placed at the height of 2.25 m. to 2.75 m. (7 ft. 4 1/2 in. to 9 feet) above the ground.

The railways supply, place and maintain the St. Andrew's cross signals. The advance signals have up to the present been supplied by a commercial organisation, the railway limiting itself to supplying the supports and erecting the signal.

Only a few tests have been made with signals warning the road users of the approach of trains with the wig-wag apparatus and the Signum apparatus; a Magondeau apparatus is about to be tested. These level crossings have during these test periods been the object of a secret supervision.

The Lower-Congo to Katanga Railway simply uses a road situation signal without reflector which is put into position by the Company.

Denmark. — At the present time at all level crossings without keepers the international signal has been put up with in addition a disc bearing the word « Beware of the trains ».

A new system of protection is under investigation with the object of establishing the following set of conditions :

1. on each side of the track and near it is placed a crossing signal consisting of a St. Andrew's cross, painted in red and white bands;

2. at a distance of between 150 and 250 m. (492 to 820 feet) from the centre of the nearest track, the international signal;

3. finally, at a distance of about 100 m. (328 feet) from the crossing a police notice board advising the road users not to exceed a maximum speed of 20 km. (12.4 miles) per hour.

These signals are not fitted with reflectors; their height is about 2.50 to 3 m. (8 ft. 2 in. to 9 ft. 10 in.).

The posts are installed in conformity with the proposal of a departmental Commission and the costs are at the charge of the Ministry of Public Works.

The Commission in question can decide that apparatus warning of the arrival of a train has to be erected at unprotected level crossings when the visibility is insufficient. This visibility is arrived at in the following manner : On

the road and about 30 m. (98 feet) from the nearest track, the railway lines ought to be visible from both sides for a distance of about 200 m. (656 feet). Furthermore, from the road at 10 m. (33 feet) from the railway it should be possible to see the railway line from both sides over a length of 300 m. (984 feet).

When the crossing is at a sharp angle with the railway, the above figures ought to be increased in a certain proportion. In the same way if the road runs down towards the level crossing the distances are increased. If a building hinders the view of the railway immediately before the crossing, the visibility is considered as good if it has a satisfactory field of view before the obstacle in question.

The signal gives a red flash light when the train approaches, which light is extinguished after it has passed. The lamp is placed at a distance of about 5 m. (16 1/2 feet) from the railway on a crossing signal of the pattern we have mentioned above. This signal then carries the notice : « Stop for the flash ».

The number of these signals is so far too small to form any definite conclusions.

Spain. — We will observe first of all that the question of protecting level crossings without keepers is not yet settled and is being investigated by the technical services of the Central Aragon Railways.

This protection is not obligatory on the North of Spain Railways. However a Commission is at the present time investigating the improvement of the working of these level crossings and the use of the international advance signal as well as the position signal in the form of a St. Andrew's cross.

These signals will be rendered luminous by means of reflectors : in particular the advance triangular signal will include a reflector, one on each side of the triangle.

The height above the ground of these signals will be 2 m. (6 ft. 6 3/4 in.) for the triangular signal and 5 m. (16 feet) for the St. Andrew's cross.

The advance signals will be erected by the road services while the others will be put up by the Company.

On the Madrid-Saragossa-Alicante Railway the international signal is placed at all the level crossings without keepers and is fitted with reflectors. On the other hand the St. Andrew's cross signal is not used. In addition, 10 m. from the line a notice « Beware of the trains » has to be placed.

The situation is practically the same on the Andalusian Railways.

Up to the present signals warning of the approach of trains have not been used.

Finland. — The international advance signal is obligatory. Public level crossings have either the St. Andrew's cross signal or the old pattern notice board with the inscription « Beware of the trains ».

Some signals have also been fitted with reflectors for test purposes.

The advance signals are placed and maintained by the road authorities; on the other hand the crossing signals are left to the charge of the railway company. A number of automatic bell apparatus with A. G. A. or winking lights have been erected. These appliances have as a general rule behaved satisfactorily.

Italy. — The installation of the international advance signal replacing the old notices is in course of realisation at all level crossings without keepers.

These are also fitted with the position signal consisting of a St. Andrew's cross or by rectangular notices.

The St. Andrew's cross signal with several arms has not been adopted. To indicate the presence of a double track a notice board bearing the words « Double track — Double danger » is provided in addition to the signal.

A number of signals have been fitted with reflectors by the Italian Touring Club.

The advance signals are put up and maintained by the road authorities. Signals announcing the approach of trains have been erected for trial purposes at level crossings where many accidents have occurred or at level crossings situated on very important roads with heavy traffic. These appliances all have the following general features :

— Optical signalling clearly visible during the day by means of semaphores, discs, etc.;

— Light signals by day and by night;

— Acoustic signalling.

These signals operate at least 30 seconds before the train passes and cease immediately after the train occupies or passes the level crossing. The working of these devices is assured by various methods, but bars, levers struck by the train, flexible transmissions, or appliances fitted to the locomotive or rolling stock are not allowed. In case of the equipment getting out of order a special warning is given.

These devices are of the following types : the wig-wag 2-aspect or 3-aspect type, the Gazzani 3-aspect type, the 3-aspect Riccardi type, and the 3-aspect Barduzi type. In all there are at the present time 71 equipments in use.

As a result of the small number of equipments installed, it has not yet been possible to ascertain if safety has been improved by the use thereof. It must be remarked however that at certain level crossings fitted with signals announcing the approach of trains, accidents have occurred although the equipment appeared to be in perfect working order.

Luxemburg. — The international signnal and the St. Andrew's cross are not yet used. At the present time the notice boards : « Beware of the trains » are still in use.

Neither reflectors nor signals announcing the approach of the trains are used.

Norway. — The advance signal is erected by the Bridges and Roads Service at all level crossings it considers desirable.

The railway has installed St. Andrew's crosses at all these level crossings.

Reflectors have not been used except in one single case for trial.

At some level crossings, signals have been installed announcing to road users the approach of trains. There is no administrative regulation rendering this installation obligatory. It has been done by the railway company for reasons of economy, or on account of local circumstances.

Luminous signals of the model adopted by the International Union of Railways alone are used. Tests were made some time ago with the American wig-wag system of signals but the results were not very conclusive, as in order to give liberty to the road circulation they had to be placed very high above the middle of the road.

It is not yet possible to give any indication as to the efficacy of this method of signalling.

Holland. — The advance signal has only been placed at the level crossings indicated by the State Control. In this case it is placed 250 m. (820 feet) away. On the other hand, all level crossings have the St. Andrew's cross position signal. The visibility of these level crossings is improved by wood edgings painted in red and white on both sides of the road. At several level crossings winking orange coloured lights are fitted.

All these signals are fitted with reflectors and are placed about 2 m. (6 1/2 feet) above the ground. The advance signal is erected and maintained by an Automobile Association, the St. Andrew's cross signal by the railway.

Automatic appliances announcing the approach of trains have not been used.

On the East Indies Railways the use of the two signals : the advance signal and the St. Andrew's cross signal is obligatory, and is at the cost of the railways. On the other hand, there are no signals automatically announcing the approach of trains.

Portugal. — In Portugal although the number of unprotected level crossings without keepers is fairly great and moreover is being increased, there is no signalling at these level crossings.

On the Lourenço-Marquès Railways there are some signals of the international type, but they are rather rare.

Sweden. — The use of the international signals is not yet very widely spread in Sweden but a Royal decree of the 12 June 1931 renders this signal obligatory; consequently in the near future they will be set up at all level crossings.

A large number of level crossings without keepers are provided with the St. Andrew's cross signal, though the use of this is not yet obligatory. These signals are not fitted with reflectors and are placed at about 2 to 2.75 m. (6 1/2 feet to 9 feet) above the ground.

Automatic signals announcing the approach of trains are used on the Grängesberg to Oxelösund Railway, and on the State Railways in all cases in which the visibility is not sufficient. The number of arrangements so far put into service is considerable; for example on the State Railways, 282 replace the old gates, 125 are fitted at old level crossings without keepers, and 7 have been set up at new level crossings.

They are of the « Gasaccumulator » (A. G. A.) automatic winking type.

The administrations who have used these appliances appear to find them very satisfactory.

Switzerland. — The installation and maintenance of the international advance signal has been left to the authorities responsible for the supervision of the road. On the other hand at all level crossings with keepers these signals are placed immediately adjoining the railway.

On this subject the Federal Regulations include especially the following prescriptions :

a) when there is optical and acoustic signalling, the gates are replaced by winking light signals formed by a triangular plate with 3 red lights and a warning bell or hooter.

The winking of the lights and the ringing of the warning bell should commence 30 to 45 seconds before the train passes and cease when the last wagon of the train has cleared the crossing. The number of winks shall be about 80 per minute.

b) when there is a simple indication by means of warning signals the large signal in the form of a St. Andrew's cross, with red border and white ground must be used uniformly.

These signals are not fitted with reflectors. They are placed on each side of the line and 2.90 to 3 m. (9 1/2 feet to 9 ft. 10 in.) above the ground. Exceptions may be allowed to these rules. When it is a question of roads with little traffic for example, the use of a signal with a single winking red light, or a small signal in the form of a cross with a red edge on a white ground is allowed. The railway administration has to place and maintain these signals at it own cost.

Except for a certain number of the wig-wag type signals, installed for trial, warning signals with winking lights and electric bells are used to announce the approach of trains.

The decision as to which level crossings shall have these warning signals is made by the Federal supervising authority. The devices are automatically operated by the train by means of a contact placed on the rail. The electric

current is supplied either from a contact line, from the public light mains, or from batteries.

The Federal Ordinance is of too recent date for the number of these installations to be considerable and consequently it is not possible to draw any information from them.

France. — As far as the large companies are concerned our enquiry into the protection of level crossings without keepers had to consider two cases :

1. Level crossings the normal condition of which does not include gates (application of the law of the 26 March, 1897).

At such level crossings the use of the advance and position signals is not obligatory and in actual fact such protection only exists in very few cases. It should also be noted that owing to the very strict conditions under which the law of 1897 is applied, these level crossings are those over which both the road and the railway traffic is particularly small. Nevertheless the international signal has been placed at a certain number of them, by touring associations and by industrial firms; in this event it is placed at a distance of 250 m. (820 feet) of the railway on both sides. The P. L. M. Railway puts up in front of all these level crossings a warning notice : « Beware of the trains ».

As to the St. Andrew's cross position signal, certain systems have placed this signal at those of their level crossings the visibility of which is poor, or over which the road traffic is considerable.

The advance signals alone are fitted with reflectors; the St. Andrew's cross signals are not fitted therewith. These signals are placed at a height varying from 2.40 to 2.85 m. (7 ft. 10 1/2 in. to 9 ft. 4 in.) above the ground.

Signals announcing automatically the approach of trains at level crossings are not used by the French railways. The Nord Railway has installed such apparatus at three of the level crossings as a test. These appliances announce the approach of the trains by lights with changing colours. These signals are automatically operated by the train by means of relays and track circuits of such length that the warning takes place at least 20 seconds before the fastest trains pass the crossings. These arrangements installed at level crossings normally attended by keepers only function from 9 p. m. to 6 a. m. when the level crossing keepers are off duty and their gates are left in the open position.

These tests have not been sufficiently extensive to be able to draw any information from them.

2. Level crossings the gates of which have been abolished as a trial (Ministerial decision of the 12 July 1926).

In order to find signalling methods suitable for taking the place of the watching of level crossings, the Minister of Public Works, by instructions of the 12 July 1926, ordered the Nord, P. L. M., Orleans, Midi and State Railways to do away with keepers at certain crossings which were provided with gates and at which keepers were stationed, but at which the railway and road traffic was small, and at which the visibility round about was good enough for the experiment not to be dangerous, and to replace the keepers by installing on the road the following signals :

1. at 250 m. (820 feet) an advance signal formed by a triangular board of the international pattern;

2. near the level crossing a warning signal formed by a St. Andrew's cross with single or double arms according as the crossing in question was over one or several tracks. In a certain number of cases to this signal was added a winking yellow light working by acetylene.

The list of these level crossings was drawn up by the Ministry, after hearing

the railways, amongst those fulfilling the three following conditions :

a) Railway traffic not exceeding in both directions taken together 40 regular trains daily nor 4 regular trains in the 60 minutes of heaviest traffic during the day, and only including usually either permanently or seasonally a small number of special or optional trains so that these totals shall not be exceeded very much;

b) Road traffic, not exceeding in both directions together about 100 vehicles a day including motor-cycles, but not including bicycles; furthermore no account was taken of level crossings over which, because of the proximity of institutions such as schools or factories, there is a heavy pedestrian traffic at certain hours;

c) Good visibility of the crossing, both from the road and from the railway.

Furthermore the same signals were installed at a certain number of level crossings without keepers, but over which the traffic, whether railway or road, was fairly great or the visibility indifferent.

It was also recommended that the keepers of level crossings, at which originally there were keepers, should watch the neighbourhood of the level crossings at the times at which the trains were expected in order to intervene in the event of there being any danger of an accident occurring.

Without prejudging the results of these enquiries, we can say that if in general practice accidents at level crossings have had to be deplored quite a number have been avoided by the intervention of the keepers under the conditions mentioned above.

Moreover almost all the accidents which have taken place have occurred on level crossings on the French Nord railway where at a certain moment it was thought that this discreet watching could be suppressed.

We may point out finally that the position signals have been installed by the railways at their own cost. As regards the advance signals they have been erected principally by the road services, but certain municipalities having raised difficulties certain of them have been put up at the cost of the railway.

On secondary and local railways the situation varies from one department to another. As a general rule it may be said that the signalling of level crossings without keepers is not obligatory, but that in spite of this the use of the international advance signal is increasing more and more. On the contrary the St. Andrew's cross position signal is little used.

As regards signals automatically announcing the approach of trains, such signals are not used at all.

Most of the colonial railways do not protect their level crossings without keepers. However some systems have taken the initiative of introducting such protection; in such cases it is done by notice boards of varying forms and aspects.

CHAPTER IV.

Opinion of the administrations consulted.

We submitted to the different Administrations a last question, as follows : What according to them were the steps to be taken to improve, keeping in mind the modern development of road circulation, safety at level crossings, whether the level crossings had keepers or not.

The replies sent us are as follows.

Belgium. — According to the Belgian National Railway Company it appears that the best way of improving safety while crossing would consist in providing at the level crossings signals automa-

tically announcing the arrival of the trains, but that these signals had not yet been perfected and were very costly. They required constant supervision and very careful, i. e., very expensive maintenance.

At the present time this Company considers that the best safety measures are the following :

1. Level crossings with keepers. — The keepers should be under the impression that they are constantly supervised and should know that they will be severely punished if they are found neglecting their duty.

Their duty should be facilitated as much as possible by placing them at the most suitable observation and operating position for the safety of the trains. If the visibility is not sufficient the arrival of the trains should be signalled to them by the next crossing keeper of the station staff or that of the nearest block box. This advice can be made by horn, or by means of more highly developed electrical arrangements. If the level crossing is very important, the keeper should also be provided with a telephone and a register in which to record each train advised.

It should be understood moreover that these methods of advising the trains are provided to facilitate the work of the men, but do not in any way relieve them of responsibility.

At important level crossings, the gates may be interlocked with the permanent way signals although this system is criticised owing to the rigidity it introduces in the way of working the gates.

2. Level crossings without keepers. — These should be provided with fixed protecting devices which should be clearly visible and be maintained in good order. The field of visibilty for the road users should be such that the driver of a road vehicle using ordinary care should be able to cross such a level crossing without running any risk of being caught by a train. To get this visibility, the neighbourhood of a level crossing should be cleared of all obstructions and in particular, should it be necessary, the keeper's cottage demolished.

Denmark. — The Danish State Railways are of the opinion that the best steps to improve safety at level crossings are :

1. Preliminary warning given to the road users that they are approaching a level crossing with keeper, and good visibility of the gates of this level crossing;

2. Preliminary warning to the road user of the presence of a level crossing without keeper and good visibility from the road onto the railway, the distance of visibility being proportional to the speed of the trains. If this visibility is not sufficient it is to be supplemented by means of optical signals for announcing the approach of trains.

Spain. — According to the Madrid-Saragossa-Alicante Railways, the most desirable steps to be taken are the following :

1. Level crossings with keepers. — Road signals acting with the gate, the level crossing keeper being warned by telephone of the approach of a train.

2. Level crossings without keepers. — When the traffic is very great, signals on the road and warning of the approach of a train.

The Central Aragon Railway Company considers that the largest number possible of level crossings should be abolished and replaced by over or under bridges.

Finland. — The Finnish State Railways have sent us the following suggestions :

1. In the case of level crossings with keepers with very heavy traffic, the best gates are those which are provided with

optical signals and powerful bells, and those fitted with good reflectors. These conditions are especially important if, when the visibility on the railway is bad, the gates are equipped with devices automatically announcing the approach of a train.

2. In the case of level crossings without keepers, with nevertheless important traffic, optical and audible signals entirely or partially automatic announcing the approach of the trains are recommended.

At level crossings with little traffic, in addition to the crossing signals and the triangular signals, care should be taken to see there is good visibility, the road user being himself responsible for his own safety.

Italy. — The Italian State Railways consider that as regards level crossings with keepers, it is desirable to continue the tests carried out in Italy by the road services, whereby the road user is warned at a sufficient distance when the visibility of the gates is insufficient.

As regards level crossings without keepers, the use of warning apparatus should be made general; however this Administration considers that the real solution consists in replacing level crossings on roads with heavy traffic by under or over bridges.

Norway. — The Norwegian State Railways consider the most desirable arrangement to be that which consists of automatic winking signals with red and white lights. In the case of level crossings situated in towns, however, it is preferable to retain the level crossing keepers.

Holland. — The Dutch East Indies State Railways are of the opinion that in addition to the conditions requiring prompt advice, and perfect visibility at level crossings, both those with keepers and those without, there should be a legal prescription requiring road vehicles to slow down when approaching level crossings.

Sweden. — The Swedish State Railways consider that the most efficacious methods for diminishing the number of accidents at level crossings would be to instruct the road users to observe better discipline by making them understand more closely the bearing of the safety devices prescribed and the necessity for absolute obedience to the signals.

Another more radical solution consists in suppressing level crossings.

This is also the opinion of the management of the Göteborg-Smaland-Karlskrona Railways.

Switzerland. — In the case of the Swiss Federal Railways the requirements of the Ordinance of the 7 May 1929 are the most likely to assure safety at level crossings, whether this safety be obtained by gates or by optical and acoustic signalling, by means of signals worked by employees of the railway; or automatically by the train, or by a simple indication of the existence of the crossing given by means of warning signals.

France. — All the principal French railways have agreed to divide the level crossings into three groups :

1. Level crossings with keepers with gates normally closed;

2. Level crossings with keepers with gates normally open;

3. Level crossings without keepers and without gates.

1. In the first group the gates are only opened when someone wishes to cross. The level crossing keeper has only to make certain that there is no likelihood of any train moving over the crossing before the vehicle has time to clear the railway line. If the visibility is sufficient the keeper can satisfy himself as to this condition without difficulty. If visibility is restricted, it is desirable on important lines to warn the level crossing keeper of the approach

of trains (except level crossings which are little used, or those near which are fixed signals which give the keeper the necessary information as to the approach of the trains).

2. In the case of the second group the keeper has to shut the gates when a train is in sight or expected. From this moment, the position is the same as in the previous case. The arrangement whereby the gates are open facilitates road traffic but requires special measures so that the gates shall be shut before the train arrives. With this object, on lines on which the times the trains pass are known to the keeper, the gates have to be closed 5 minutes before each train passes. When the train timings are subject to alterations outside the knowledge of the keeper, the level crossing is fitted with a warning device (bell, electric bell, telephone, etc.).

In order to reduce to a minimum the interruption of the road traffic the gates of important level crossings are of the lift-up type, and are both worked at the same time.

3. In the case of level crossings without gates the road users have themselves to look after their own safety. With this object, except in the case of level crossings where the road has only an exclusively local traffic, the users should be very clearly warned : 1. of the presence of the level crossing; 2. of the fact that there are no gates.

With this object it is desirable to erect at the level crossing the St. Andrew's cross adopted by the International Railway Union (decision of the Managing Committee of the 8-10 November 1926) and if this is not visible from some distance the level crossing is in addition signalled by a road signal of the international type (triangular plate with an outline of a locomotive).

If the driver of the vehicle has not sufficient visibility onto the railway, the arrival of a train must be made known by special means, as for example : the locomotive whistle.

In the case of secondary railways and light railways, we would point out that on the General Light Railway Company the use of road signals with reflectors is being extended and the speed of automobiles running over the level crossing is limited to 15 km. (9.3 miles) per hour.

In the opinion of the Departmental Railways Company, a telephone with polarised relays should be fitted in the level crossing keeper's houses and the drivers' attention should be called to the presence of a level crossing without keeper by a post placed 200 m. (656 feet) away on the railway, and that of the road users by a post at the same distance on the road.

The Light Railways think that the method of warning by signals fitted with reflectors is all that is needed.

The Nord-Est Railways think that level crossings without keepers should be announced by a warning signal of uniform pattern with a large reflecting surface, placed 200 m. from the level crossing. The value of this signal could be usefully added to by painting white the trees or the posts along the side of the road.

In addition a board « Beware of trains » should be placed by the railway as close as possible to the level crossing, at such a distance from it that a vehicle stopped at this signal is clear of the loading gauge.

All vehicles warned of the approach of a level crossing should slow down sufficiently to be able to stop at the warning signal if a train is visible at this point or announced.

Drivers of motor vehicles should in addition be advised not to change gear while running over the railway.

If the visibility is insufficient near the level crossing, the train should call attention to its presence by whistling. The distance at which the train should call attention to its presence in this way

should be such that when its speed is taken into account, it will not require more than 12 seconds to reach the level crossing.

The Colonial Railways as a whole consider that the methods of protecting by warning signals placed at the present time is sufficient in view of the small road traffic at the crossings.

CHAPTER V.

Discussion.

From the preceding study we see that all the Administrations of the railways covered by our report have endeavoured, either by new regulations or by technical arrangements, to improve the safety at level crossings and to make easier the conditions under which the road traffic crosses the railway. The experiments however have been carried out during too recent a period and have been applied to cases frequently too limited for any general opinion to be drawn from them as yet.

In a table attached to the present report (appendix) we have grouped together the statistical information that the various Administrations have been good enough to send us. In particular the number of accidents occurring during the years 1928, 1929 and 1930 at level crossings of the different types will be found therein.

* * *

In order to put the question in its proper place we will consider it from its origin, asking to be excused if this method obliges us to state certain truisms.

Safety at level crossings is a particular case of a much more general problem : safety at the crossing of two given lines of communication. The object to be attained is to prevent vehicles from trying to cross in different directions at the same time, and there is but one method of attaining this object : stopping one of the movements of traffic to let the other pass.

In considering the measures to be taken two factors must be considered :

— density of the traffic on each of the lines;

— braking distance of the vehicles on each of the lines.

But whatever may be the respective importance of these two factors the object sought after cannot be realised unless a system *of signalling* with suitable *regulations* is introduced. We would moreover remark that regulations are only an adjunct to the signalling as they have no other action than to give a meaning to the signals.

Let us take for example the case of the crossing of two roads where there is no special method of signalling because the visibility at this point is good, or because on one or the other only slow running vehicles pass and consequently the braking distance may be disregarded. In this case the driver of one of these vehicles only needs a signal given by the vehicle running onto the crossing track and the regulations only fix the relative priority of one line over the other.

Thus at the crossing of two lines there is always a signal, of varying form, it is true, but it has always the same meaning, it is an absolute *stop signal.* Whether this be the white baton of a policeman or the red and white chequered board of the French railway signal, any failure to observe this signal in practice leads to disaster.

Finally, the signals controlling the two lines should be *interlocked,* i. e. when one of them allows passage the other should require the traffic to stop. In the case of the example given above, interlocking is replaced by the priority of one road over another; in that of the road police at the intersection of two roads this interlocking is obtained by

the fact that the policeman has a white baton, and one only.

The preceding principles are applicable to level crossings But in this case they should be amplified owing to the special nature of the lines which cross thereat.

As one of the lines is a road and the other a railway, the regulations should give the latter priority over the first as in the case of vehicles running on the railway the braking distance is considerable, stopping and starting being much more complicated than for the road vehicles; furthermore, as a train cannot pass another on the railway except in stations any stop between stations results in delays in the working and consequently is a source of danger; finally, all the trains serve the public interest while most of the road vehicles are for the use of individuals. Consequently the signalling of a level crossing shall have this particular aspect : it can prevent road vehicles coming onto the crossing, but it must only interrupt the railway traffic when for some reason it is impossible to stop the road traffic.

The road signals can be of three kinds, which may be arranged in order of increasing efficacy, in the following way :

— fixed signal indicating the nearness of the level crossing;

— signal announcing the approach of the train;

— gates.

In fact the gates of level crossings must be considered as being a signal; and it is the signal which possesses most definitely the character of the absolute stop signal that we have shown as being compulsory.

Now a road signal should show this characteristic in a more insistent way than a signal on the railway and for the following reasons :

1. The driver of a train is a man subjected by the railway to strict discipline; he knows that he must give complete obedience to the signals and frequently control devices make it possible to check if he has done so. The driver of a road vehicle on the other hand is independent; he will not take any notice of the signal unless he is obliged to, either by some material constraint or by an immediate view of the danger;

2. On the railway as on the road, failure to observe a signal creates a danger, but whereas in the first case this menace persists until the accident occurs, in the second case it only lasts a short moment : the period in which the level crossing is passed over. This is what explains the difference of mentality of the driver of the train and of the road user : on running past a signal at danger the first will *unavoidably* have an accident, whereas the second *simply risks* having an accident.

Certain Administrations are considering the general replacement of gates by a signal, either for reasons of economy, or because of the inconvenience caused to the road traffic. In order to be able to give on this subject a well-justified opinion, it is necessary to translate these considerations into figures.

In the case of the former, let us place ourselves in the position of replacing the level crossing keeper by a signal with a winking light not announcing the approach of a train : the annual cost of the operation is as follows :

Amortisation and interest on the capital involved (6 200 to 6 300 fr.)	700 fr.
Maintenance	1 000 fr.
Total . . .	1 700 fr.
Annual saving of level crossing supervision and maintenance of gates	3 000 fr.
Annual saving . . .	1 300 fr.

This figure should however be reduced considerably for the following reason : the day when the wives of the permanent way men cease to be level crossing keepers the permanent way men will require an increase in pay to take into account on the one hand the loss of income that would result and on the other the loss of living accommodation the alteration would involve.

If a signal calling attention to the approach of trains is installed this financial balance sheet will be still less favourable and may even show a loss.

It is also necessary to take into account the whole of the costs which the railways will be responsible for to improve the visibility near level crossings without keepers : clearing away trees, levelling off banks, etc.

It can therefore be said that the suppression of the level crossing gates and of the keepers would be a profitless operation from the financial point of view if for the railways it had not another result : the removing in case of accident of the civil responsibility which falls on the railway every time the gates are found open through the fault of the keepers. By a pysychological process which is quite easily appreciated, the above reason explains the energy with which certain administrations are taking steps to obtain the suppression of gates at level crossings, but for the same reason the Governments ought to act with great care in order to avoid a change in responsibility to the detriment of the road users.

In examining the measures to be taken at level crossings, it is also necessary to distinguish between *danger* and *inconvenience* caused to the road traffic.

As regards danger, there is first of all an important factor : the visibility of the railway from the road. Obviously no general rule exists to measure this danger. The diagram of visibility or rather the visibility plan of which we have spoken above may give exact information on this point.

But putting aside this question of visibility, the danger can be measured by the probability, in the case of a road vehicle, of running onto a level crossing just before a train is to pass. If it is agreed that it is dangerous to cross during a period τ before the level crossing will be run over by the train, if n is the number of trains that pass during the time T, the probability for *one* vehicle to run onto the level crossing at a moment when there is danger is obviously : $p = \frac{n\tau}{T}$. This number represents the *coefficient of danger*.

It would of course be possible to introduce into this expression the visibility, seeing that the absence of visibility constitutes in fact an increase of the period τ during which there is danger.

However this may be, the coefficient of danger so defined only depends upon the railway traffic.

As to the *inconvenience* caused to the road traffic, this is measured, if it is accepted that the gates or the stop signal is against the road traffic for a period of time τ by the *probable number of vehicles stopped*, i. e. $Np = Nn\frac{\tau}{T}$.

The *probable number of accidents* is, all other things being equal, proportional to this expression.

These considerations make it possible to understand the interest that the population taken as a whole may have in the suppression of a level crossing.

Actually, the *loss of time* caused to each vehicle stopped will be equal to $\frac{1}{2}\tau$ increased by the time lost for braking and starting, i. e. τ'.

The total loss of time will thus be for each interval $T = Nn\frac{\tau}{T}(1/2\,\tau + \tau')$.

If we know the average price per hour of utilisation of a vehicle we will also

have the value in money of the loss caused to the country as a whole by the level crossings, and we will thus be in a position to consider if it is to the interest of the community to suppress the level crossing and replace it by an over or under passage, or even if it is not advisable to consider a by-pass of the road traffic.

As an example let us suppose that we have $\tau = 3$ minutes and that it is considered that during the day the interval T to be taken into account is 15 hours, i. e. 900 minutes. We should have $p = \frac{n}{300}$. The probable or average number of vehicles stopped will be $\frac{1}{300}$ Nn.

Supposing that we have on the average $\tau' = 3.5$ minutes, from which $1/2\tau + \tau' = 5$ minutes, the loss of time per day will be : $\frac{5}{300}$ Nn $= \frac{1}{60}$ Nn minutes, i. e. $\frac{Nn}{3\,600}$ hours per day, and approximately $\frac{Nn}{10}$ hours per annum.

If we agree that the average price per hour of utilisation of the road vehicles is 10 fr., Nn represents the anual loss in francs to the community.

It can be seen that if there are 100 train movements daily on the railway and 500 road vehicles on the road, the annual loss will be 50 000 francs. The suppression of this loss through doing away with a level crossing would make it possible to spend 1 000 000 francs in capital which would be added in a balance-sheet affecting the community itself to the capitalisation of the saving of watching the crossings, as well as naturally doing away with the risk of accidents.

To return after this slight digression to the question of the steps to be taken at level crossings, we consider that each time that the coefficient of danger is high, i. e. each time that the railway traffic is great or the visibility is bad, the stop signal to be shown should be *in principle the gate.*

At other level crossings, an optical or sound signal should be sufficient.

We are therefore led to consider two classes of level crossings :

— level crossings with keepers;
— level crossings without keepers.

Level crossings with keepers.

Whatever the system of level crossing supervising be, safety depends upon the vigilance of the crossing keepers. Although any individual may fail to carry out his duty, the operation of an apparatus by an employee will always be more certain than that of any automatic appliance however perfected it may be, and certainly so when the energy required has an appreciable value as in the case of the gates at level crossings even when well balanced.

In spite of that it is essential that the possibility of the employee failing in his duty should be reduced to the minimum by means of certain precautions :

1. *Recruiting level crossing keepers.* — In all countries, the working of a level crossing is carried out by the following staff :

Day time service : in most cases the work is done by the wives of men and they are allowed between the trains to attend to their household duties. At level crossings where the traffic is heavy a man is employed as keeper.

Night service : in all cases where this work is done it is covered by a man.

This method of recruitment is not only wise but is also economical, and there is no reason for changing it. But those responsible for nominating the level crossing keepers should not forget that these men are *safety agents* and that they should be suitable for fulfilling this duty.

Male crossing keepers are often recruited from men of other departments

who are no longer fit for full duty. Undoubtedly it is humane to endeavour to use men who have no longer sufficient strength to cover their normal duties, but to allot them to level crossing work should be done with care and it should be ascertained if their physical strength has suffered or if their intellectual faculties and their mental reactions have not changed.

In a more general way no level crossing keeper should be engaged without having undergone an examination by which his superiors can ascertain his knowledge of the signal regulations and of the special regulations applying to his work. It is also desirable to inquire into the moral character of the candidate, and in particular into his sobriety, and to have him examined by the medical service. The statistics of accidents at level crossings in France, through mistake of the keeper show that in the majority of cases this man was either addicted to alcohol or was too old.

We will recall certain other conditions which are imposed by the Portuguese railways and which appear to us of value : the level crossing keeper should be able to traverse a distance of 1 000 m. (0.62 mile) in a maximum time of 9 minutes, and to distinguish at this distance green and red colours.

Once appointed, the keepers should be constantly supervised by their superiors, so as to know that they are always capable of doing their work. We recommend in particular surprise visits by motor car, by the engineers of the railway. Finally the drivers ought to report every failure to comply with the regulations which they observe in running.

These prescriptions ought to be the object of very carefully worded instructions.

2. *Advice of the approach of trains to level crossing keepers.* — In most cases the keepers are completely isolated. They have only a working table of the trains which shows the booked time the train should pass. But as soon as anything goes wrong with the timetable they have no longer anything but the one source of information : a direct view of the train. If the visibility is normally good this method of obtaining information is of value, but even in this case this value can be appreciably diminished either by fog, by darkness, so that there is always an excuse available. Furthermore the keepers are not warned of exceptional trains : not only is the system of announcing a special train by the preceding train a precarious method, but there are certain train movements that cannot be announced in this way, such as for example assisting engines.

Consequently the working timetable cannot be taken as anything more than a basis, an important one, but quite insufficient for the level crossing keeper and it should therefore be completed by some other means of announcing the trains. Before we consider the appliances for announcing the trains, we may call attention to the fact that the utility of the working timetable is not very real unless the level crossing keeper is provided with a good watch. Certain railways supply such a watch, but most of them leave the provision of a watch to the care of the keeper himself. This method appears to us undesirable as it is not as certain as it should be : the railway ought to fit the cottages at level crossings with a clock or chronometre and should arrange for it to be regulated by the permanent way men who can regulate their own watches at nearby stations.

This said, the apparatus for announcing trains are of two types :

1. Apparatus controlled by another man, Jousselin, telephone, indicator board, etc. This is undoubtedly the best arrangement, and that which gives the greatest guarantee on condition that

its use also requires the inscription of the message received in a book supplied for the purpose. This is the method that ought to be used at all level crossings on important lines owing to the intensity of the railway traffic.

This system makes it possible to place telephones at intervals along the line, a matter of great interest in the case of accidents or untoward happenings.

2. Apparatus announcing the train, controlled automatically by the train by means of a bar. This system is less costly but also less sure, on account of failures, rare it is true, which may occur. It should therefore be used on secondary lines only.

In this case it ought to be clearly understood that the failure of the apparatus to work does not relieve the level crossing keeper from his responsibility.

Naturally it may be objected that installing such apparatus will involve considerable cost, but on the one hand the reason of economy loses part of its value when it is a question of safety; on the other, these installations may be installed in stages to help the budgetary position. The number of such installations may moreover be reduced by the distant control of the crossing.

This distant control can be provided in two cases :

1. In the case of level crossings situated beside a station or a block post, the operation can be confided to the men of the station or the block post, as these men are well informed as to the times the trains are due and they have in general an excellent view of the immediate neighbourhood of the level crossing. In the case of elevated block posts, this visibility is very often better than that from the level crossing keeper's house;

2. When several level crossings are placed at short distances from one another, and there is no great road traffic, the gates can be operated from one of them, even if the level crossing thus distant operated are not visible from the level crossing keeper. But in this case, it is necessary that the gates should be closed slowly and that the closing should be preceded by the ringing of a bell. It is also necessary that the road users should be able to ask for the gates to be opened by means of a bell.

Another arrangement has been used : this consists in the interlocking of the level crossing gates with the *usual track signals* (section signal or block signal). The above enquiry shows however that the Administrations are unanimous in limiting the use of this arrangement to existing installations : it is criticised as lacking flexibility and also interfering both with the working of the railway and with the traffic on the road. Moreover, it can only be carried out in very few cases : first of all it is necessary for the level crossing to be near a section signal on the one hand, or for the line so operated to be under the regime of signals normally at danger. For these reasons this arrangement does not appear to us of value, and, in agreement with the Administrations, we consider it ought to be abandoned.

On the other hand we have indicated at the beginning of this chapter that the interlocking of the signals of the two crossing tracks was an indispensable condition of safety at the point of intersection of the two tracks. The signalling of level crossings should not fail to follow this rule, but owing to the priority that one of them should have over the other, this interlocking should meet the special conditions which may be summed by in the following way :

The road signal (in actual practice the gates) should be put to danger when a train is approaching but, if for any given reason this signal remains open, the driver ought to be warned thereof. A large number of arrangements meeting these conditions can be thought of. We will

mention as an example the following which seems to us valuable owing to its simplicity. On the railway line, at a suitable distance, on each side of the level crossing a signal is erected which may be either a stop signal (red disc of the French signalling system) or a special signal. This signal is interlocked with the gates so as to be clear when the gates are closed and inversely. Priority is given to the railway by the instructions whereby the keeper is required to close his gates when he is advised of a train either by telephone or by a warning arrangement the pedal of which will be placed at 2 000 m. (1.2 miles) from the level crossing. But if for any reason he is unable to do this, the driver will find the signal at danger and will be able to stop before reaching the level crossing.

The introduction of this arrangement will, it seems to us, improve very considerably the safety at level crossings as it prevents danger to the road user through any mistake committed by the level crossing keeper, and it is desirable that it should be folllowed up systematically in relation with the improvement of the methods of announcing the approach of the trains.

One of the essential qualities of a good signal is perfect visibility. This condition should be realised in the case of level crossing gates.

The visibility in the day time will be improved by painting the top and the uprights in large bands of white and red alternately (it appears that the combination of these two colours is the most striking), and of fitting them with large white plates with diagonal red bands. In the case of lift-up gates these plates can be replaced by an arrangement of articulated bars painted red and white alternately.

At night the level crossings should be illuminated as well as possible. We recommend on this subject the method used by the P. L. M. : lamps fitted with a special arrangement projecting a luminous ray on the visibility plates of the gate; from another face of the lantern the light is visible from the road. The use of reflectors ought also to be made general on roads much used by automobiles.

The gates can be either pivoted, or rolling, or lifting. Certain administrations still use chains or ropes : this system ought to be given up as it is so difficult to see. Lifting gates are used when distant controlled : they ought also to be installed at important level crossings owing to the rapidity with which they can be operated.

Owing to the short distance in which road vehicles can be stopped, the level crossing gates need not be as a rule protected by an advance signal. However when the distance of visibility of the gates is small, for example less than 200 m. (656 feet), the international signal, a triangular plate carrying a picture of a gate, should be erected. At night this signal ought to be lighted or fitted with reflectors.

When considering the operation of gates it is usual to divide them into two kinds : gates normally open and gates normally closed. We consider however that it is a mistake to divide level crossings into two classes based on this method, because at one and the same level crossing it might be necessary to change the method according to the season or even the hour of the day.

From the point of view of safety, both schemes are of equal value, especially with the arrangements which we have specified. Moreover in the case of level crossings normally open, most Administrations require them to be closed 5 minutes, before the normal time a train is due to pass, so that at the time of danger there is in fact but *one method,* that of level crossings normally closed.

When selecting the method, other considerations should moreover be taken into account, for example the work of the level crossing keepers : that arrange-

ment should be adopted which will require the least number of operations of the gates. It should be noted that, if in the case of the railway traffic the number of operations is equal to the number of trains, in the case of road traffic it is not the same and the number of operations should be fixed by experience.

At night it is necessary to consider certain particular arrangements. On certain lines, on which there are no night trains, the gates are left open and not protected. On the other hand, on railways where the road circulation at night is very small, the gates are left closed and the keeper gets up to open them when the road users ask for this to be done.

* * *

Level crossings without keepers.

We will recall to mind that these level crossings should satisfy the following three requirements :

— Light railway traffic;
— Light road traffic;
— Good visibility of the railway.

It is difficult to lay down in any precise manner these conditions which can only be determined in each case. In the case of the railway traffic it is necessary for example, that it should only consist of trains running relatively slowly and should be figured by the number of trains during the busiest hour, by making allowance for the number of optional trains. As regards the road traffic, the type of vehicle and nature of the traffic (local traffic or through traffic) ought to be taken into account. As regards visibility, this can be determined by means of visibility diagrams analogous to that we described above.

The signalling of such level crossings can be of two kinds : fixed signals or signals announcing the approach of the trains. It would appear at first sight that the second signal gives greater safety and ought to be used at level crossings where the conditions that we have indicated are present to some extent. In our opinion, it is only in fact a half-measure; either the conditions of visibility are very good and then the signal is useless, or the visibility is poor and in this case it would appear to be better to use gates. Actually the signal announcing the approach of the trains forms a stop signal, whereas the fixed signal is simply a warning, the stop being controlled by the train itself, as the visibility is good. Now we have already indicated the lack of efficacy of an absolute stop signal consisting solely of optical and sound devices.

We are therefore hardly in favour of signals announcing the approach of the train to the road users except perhaps in very particular cases which we cannot deal with in this study.

In examining these cases, the following considerations should be taken into account, having already been more or less explicitly mentioned in the course of this investigation :

1. If the visibility is good, the approach signal is useless. The road user will generally not take any notice of it, preferring to trust to what he can see on the railway knowing that he can cross the dangerous passage in a very short time.

2. If the visibility is bad, for the signalling to be really efficacious the light indicating the danger must either show for as short a period as possible or the road user will tend not to stop as in the preceding case. But as he must not be suprised by the warning of the immanent danger a previous warning light is required to enable him to slow down beforehand to a reasonable speed.

The advance signal is not sufficient for this because, as has been said above, the stop signal cannot have any obligatory character if it is seen too long beforehand;

3. The frequency of fog must be taken into account, as the audible signal does not give the same guarantee of safety as light signals;

4. The possibility of children — or cattle — crossing must be taken into account. Obviously care must be taken not to make the safety depend on such signals in the case of level crossings currently used by school-children;

5. In all cases the question of economy ought to be investigated so as to enable a choice to be made between a gate and a signal.

As regards level crossings without keepers, with fixed (or permanent) signals, they should be fitted with the St. Andrew's cross signal either simple or double according to the number of tracks, which signal should be erected in the immediate vicinity of the level crossing, and with the international triangular signal carrying a picture of a locomotive which should be placed a distance of 150 to 200 metres (492 to 656 feet) away. These signals should be made visible during the night : in the case of the advance signal, it should be sufficient to fit it with reflectors when it is situated on roads over which motor vehicles run. As regards the position signal it should be made visible by means of a winking light in order to call the attention of the road users to it.

It is necessary for these signals to adopt the international type so that they may be well known to all road users. Multiplicity in the type of signals can only bewilder the road users and render the observation thereof less certain.

Notices ought to be posted requiring as a general rule the driver to whistle on approaching level crossings.

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The enquiry which we have made shows that in all countries the regulations concerning level crossings are issued by the State which concedes the railway and operates the road system.

In the case of some nations these regulations are old and owing to their rigidity interfere with the modernisation of the methods for securing safety at level crossings. Frequently, attempts have been made to prevent this by modifications in the regulations, but the result is a large number of rules, which does not always simplify the question. It is therefore desirable that all Governments should regulate the position of level crossings by a single and clear text, such as the Federal Ordinance does in the case of the Swiss Railways.

These regulations should moreover be flexible so as to be able to apply the best conditions in each particular case. As we have shown in the above, these regulations should not distinguish more than two classes of level crossing : crossings *with* and *without* keepers.

In applying these regulations the position of each level crossing should be defined by a decision of the Ministry to which group it belongs and should fix among other things :

1. The class of the level crossing (with or without keeper;

2. If it is a protected level crossing with keeper :

a) the type of gates to be used;

b) the method of working (gates normally open or shut), a method which can vary;

c) the staff (man or woman, operating by view or not, watching by day and by night, etc.);

d) illuminating the level crossing and the use of reflectors;

e) methods of warning the keeper of the arrival of trains.

3. If it is a level crossing without keeper, the erection of the position signal and the advance signal, and, if need be, of the notice « Whistle » or if necessary

the conditions of working of the approach signal which may be erected at the level crossing owing to its particular location.

Finally it would be necessary for the road regulations to include certain prescriptions for the road users, such as :

— Slow down to 20 km. (12.4 miles) an hour when getting over level crossings;

— No overtaking on level crossings.

— No use of change speed on a level crossing;

— Obligation to pay attention to the approach signal.

These regulations should also make clear the meaning of the various signals the driver may meet on his road.

Summary.

From the examination of the different regulations in use on the Railways we have consulted, from the observations and suggestions that we have received as well as from the considerations that we have developed in this report, it appears to be possible to conciliate the existence of level crossings with the requirements of modern traffic by means of a suitable system of signals and regulations.

Moving gates, seeing that they apply to the whole of the road users, should be considered as the most efficient signal. But in certain cases, where conditions as regards visibility, the railway traffic, and the road traffic, allow it, they may be replaced by another system of protection (fixed or rather permanent) or in some cases by approach signals.

We should then have two classes of level crossing :

1. Supervised level crossings, i. e. with gates.

These gates should be clearly visible, by day and by night.

They may be operated either on the site by special keepers, or from a distance by men already doing other work. In this case the visibility of the man on the road should be sufficient.

The level crossing keepers should be entirely satisfactory from the physical and moral points of view.

An endeavour should be made to announce the approach of trains at all level crossings with keepers, without exception.

Finally in order to prevent the fault of the level crossing keeper, who has not closed his gates when a train is announced, a fault the consequences of which may be very serious, it is desirable that these gates should be interlocked with a stop signal suitably located.

2. Level crossings without keepers.

As a rule as good visibility is required and if there is little railway and road traffic the road users should be made aware of the presence of these level crossings by a position signal and an advance signal, both visible by night as by day. The trains should whistle when approaching such level crossings.

Paris, 15 February 1932.

APPENDIX.

Statistical information supplied by the different Administrations.

ADMINISTRATIONS.	Length of lines worked, in km. (*in miles*).	Number of level crossings with keeper. — keeper on the site.	Number of level crossings with keeper. — distant controlled.	Number of level crossings without keeper.	Year.	Number of accidents occurring — to vehicles — at crossings with keeper (through the fault of the keeper). — keeper on the site	Number of accidents occurring — to vehicles — at crossings with keeper (through the fault of the keeper). — distant controlled.	Number of accidents occurring — to vehicles — at crossings without keeper.	Number of accidents occurring — to pedestrians — at crossings with keeper.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Belgium.									
Belgian National Railway Co.	4 792 (*2 978*)	2 073	526	3 863	1928	12	4	35	0
					1929	23	1	59	3
					1930	17	2	53	1
Lower Congo to Katanga Railway.	...	7	0	202	1928	0	...	1	0
					1929	0	...	1	0
					1930	0	...	1	0
Denmark.									
State Railways	2 521 (*1 566*)	765	196	3 376	1928	5	1	14	1
					1929	5	1	14	1
					1930	5	1	14	1
Italy.									
State Railways	16 858 (*10 475*)	2 621	3 161	8 053	1929	28	11	227	8
					1930	20	12	269	5
Spain.									
Central Aragon Railway.	299 (*185*)	56	1	162	1928	4	0	...	0
					1929	5	0	...	0
					1930	5	0	...	0
Madrid - Saragossa - Alicante Railways.	3 654 (*2 270*)	1 962	83	736	1928	20		4	0
					1929	37		12	0
					1930	15		7	0
North of Spain	3 762 (*2 338*)	2 507	18	1 315	1928	40	0	7	0
					1929	28	0	7	1
					1930	23	0	16	2
Andalusian Railways . .	...	233	0	885	...	...	...	...	...
Finland.									
State Railways	5 157 (*3 204*)	145	40	4 800	1928	15	0	54	0
					1929	11	0	59	0
					1930	15	0	61	0
Luxemburg.									
Prince-Henry Railway. .	193 (*120*)	93	53	84	1928	0	0	0	0
					1929	1	0	1	0
					1930	0	0	0	0
Norway.									
State Railways	3 500 (*2 175*)	...	...	...	...	...	...	...	...

ADMINISTRATIONS.	Length of lines worked, in km. (*in miles*).	Number of level crossings with keeper.		Number of level crossings without keeper.	Year.	Number of accidents occurring			
						to vehicles			to pedestrians
						at crossings with keeper (through the fault of the keeper).		at crossings without keeper.	at crossings with keeper.
		keeper on the site.	distant controlled.			keeper on the site	distant controlled.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Holland.									
Netherlands Railways . .	...	763	465	2 796	1928	7	2	49	0
					1929	16	0	47	0
					1930	9	0	53	0
Dutch East Indies Railways.	2 926 (*1 818*)	934	78	1 199	1928	2	0	5	0
					1929	3	1	7	0
					1930	3	0	9	0
Portugal.									
Portuguese Railways . .	2 464 (*1 531*)	1 301	0	1 423	1928	33	0	15	0
					1929	41	0	17	0
					1930	31	0	23	0
Sweden.									
Bergslagen Railway. . .	...	64	48	16	1928	0	6	5	0
					1929	1	5	4	0
					1930	0	9	1	0
Göteborg-Boras Railway.	352 (*219*)	35	77	9	1928	0	0	0	0
					1929	0	0	0	0
					1930	0	0	0	0
Grängesberg-Oxelösund Railway.	300 (*186*)	19	34	86	1928	10	13	5	0
					1929	9	15	4	0
					1930	8	16	4	0
State Railways	...	271	547	472	1928	0	0	...	3
					1929	0	1	...	1
					1930	2	0	...	1
Switzerland.									
Rhætic Railway	277 (*172*)	9	83	383	1930	1	2	...	3
Federal Railways . . .	2 941 (*1 827*)	898	1 330	2 341	1928	0	2	6	0
					1929	5	0	9	0
					1930	3	0	9	0
France.									
P. L. M.	9 887 (*6 144*)	5 759	969	260	1928	19	0	0	31
					1929	19	1	5	53
					1930	23	1	0	51
State	...	5 877	1 015	2 444	1928	16	3	6	16
					1929	26	0	8	23
					1930	20	0	6	25
Paris-Orleans	...	4 097	438	1 964	1928	8	0	9	31
					1929	4	1	9	32
					1930	2	1	10	32
Nord	...	1 997	335	713	1928	12	2	13	30
					1929	12	3	11	35
					1930	13	2	14	19

ADMINISTRATIONS	Length of lines worked, in km. (*in miles*).	Number of level crossings with keeper. keeper on the site.	distant controlled.	Number of level crossings without keeper.	Year.	Number of accidents occurring to vehicles at crossings with keeper (through the fault of the keeper). keeper on the site	distant controlled.	at crossings without keeper.	to pedestrians at crossings with keeper.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
France (*Continued*).									
Midi	4 290 (*2 666*)	2 877	37	939	1928 1929 1930	9 12 9	0 0 0	3 1 1	10 7 11
Alsace-Lorraine (including Guillaume-Luxembourg Lines).	2 293 (*1 425*)	1 001	494	1 152	1928 1929 1930	6 5 7	1 1 0	8 5 4	0 0 0
Ceinture (Paris Belt Lines)	152 (*94*)	51	13	0	1928 1929 1930	0 0 3	0 0 0	... ...	3 0 0
Chemins de fer Economiques.	3 552 (*2 207*)	272	55	8 552	1928 1929 1930	0 0 0	0 0 0	71 74 95	0 0 0
Chemins de fer Départementaux.	1 952 (*1 213*)	...	...	...	1928 1929 1930	0 1 0	0 0 0	20 26 21	0 0 0
Chemins de fer Vicinaux.	720 (*447*)	0	0	...	1928 1929 1930	... ...	... ...	13 19 21	... ...
Nord-Est Railways . . .	551 (*342*)	14	0	652	1930	4	...	23	0
Saint-Gobain Railway . .	15 (*9.3*)	2	2	7	1928-1930	0	0	0	0
Sud-Ouest Railway . . .	408 (*254*)	0	0	305	1928 1929 1930	... ...	... ...	11 10 8	... ...
Franco-Ethiopian Railway.	784 (*487*)	1	0	...	1928-1930	0	...	0	0
Damas-Hamah Railway .	584 (*363*)	15	0	859	1928 1929 1930	4 9 3	... ...	2 6 2	0 0 0
Reunion Island Railway .	126 (*78*)	16	0	125	1928-1930	0	...	0	0
Ivory Coast Railways . .	...	2	0	7	1928-1930	0	...	0	0
Thiès to the Niger Railway.	1 219 (*757*)	6	0	...	1928 1929 1930	0 0 1	... ...	0 0 0	0 0 0
East Dahomey Railways.	81 (*50*)	0	0	8	1928-1930	...	...	0	0

ADMINISTRATIONS.	Length of lines worked, in km. (*in miles*).	Number of level crossings with keeper.		Number of level crossings without keeper.	Year.	Number of accidents occurring			
						to vehicles			to pedestrians
						at crossings with keeper (through the fault of the keeper).		at crossings without keeper.	at crossings with keeper.
		keeper on the site.	distant controlled.			keeper on the site	distant controlled.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
France (*Continued*).									
Central Dahomey Railways.	324 (*201*)	3	0	20	1928-1930	0	...	0	0
Guinea Railways . . .	662 (*411*)	0	0	...	1928-1930	...	1	...	...
Tunisian Railway Co. .	1 584 (*984*)	19	0	1 618	1928 1929 1930	0 0 1	... ...	6 4 18	0 0 0
Gafsa Railway	...	3	0	170	1928-1930	0	...	0	0
P. L. M. (Algerian Lines).	1 250 (777)	217	4	661	1928 1929 1930	2 1 5	0 0 0	7 5 6	5 4 1
Algerian State Railways.	3 480 (*2 162*)	304	11	2 208	1928 1929 1930	2 3 2	0 0 0	14 14 12	1 0 0

[656. 222.1]

Methods of increasing the average speed in railway operation (*),

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The difference between maximum speed and average (or commercial) speed is mainly due to acceleration, gradients, and local speed restrictions. For a given maximum speed, the average speed can be raised by greater accelerations, and higher speed on gradients, by using locomotives of large adhesive weight and power, and by limiting the weight of the trains. The maximum speed is at present limited by braking distances and signal layouts to 110 km. (68.3 miles) per hour, or in favourable circumstances 120 km. (75 miles) per hour; the corresponding average speed that can be achieved in level country approaches 100 km. (62 miles) per hour. A maximum speed of 150 km. (93 miles) could undoubtedly be reached with vehicles built in accordance with present-day practice.

Average speed and maximum speed.

There is always a difference, of varying magnitude, between the commercial speed, that is the average speed of the train between departure and arrival stations, and the maximum speed. The passenger is only concerned with the actual duration of the journey, i. e. the time spent on travelling, whereas the engineer is fundamentally concerned with *speed* as a factor in the performance of his traction units. The maximum speed can depend either on the power of the locomotive or rail motor car or on regulations drawn up to ensure safe operation, or again it may be determined by economic considerations based on the fact that higher speeds can as a rule be obtained only by increased expenditure.

If a definite numerical relation existed between commercial and maximum speeds, the ratio having a fixed value which would of course be less than unity, then an increase of the commercial speed would only be possible if the maximum speed were increased, and our present investigation could be limited to considering the means by which such an increase might be effected. It is clear, moreover, that an increase in maximum speed is a particularly effective, and in fact the most direct means of raising the commercial speed. But for the very reason that the ratio varies within wide limits it is worth while to study the possibility of bringing it under some appreciable measure of control, as well as investigating whether the commercial speed, that is so important psychologically, cannot be improved without modifying the value of the maximum speed, which from first considerations seems desirable. With our present time tables the ratio varies within the limits of about 0.85 for long distance express trains on fairly level lines, down to 0.45 for passenger trains stopping at every station in densely populated districts.

Causes of the difference between the two speeds.

Let us analyse the factors which determine the difference between the

(*) Paper read on 29 June 1931, before the « Transport Section » at the Convention of the Institution of German Engineers held in Cologne.

average and the maximum speeds. Even on a level track free from special features, that would limit the maximum speed, the braking distance and still more the starting distance impose a delay which would be absent if these distances could be traversed at the maximum speed. The influence thus exerted by the starting and braking distances becomes greater as the distance between the stopping places becomes shorter. Consequently a fast train making infrequent stops, such as an F. D. (long-distance express) train, with its considerably greater distance between stops and the resulting few starts has from the outset an advantage over a passenger train that stops everywhere. Furthermore, the standing periods at stations mean another expenditure of time during which no distance at all is traversed. Nevertheless these stopping periods, which cannot as a rule be limited at busy city stations or important junctions to the one-minute stops made at small stations, are inseparable from the essential requirements of the traffic.

In conjunction with the loss of time due to starting, braking and stopping, the more or less severe gradients contribute to reducing the average speed as compared with the maximum speed. The specific resistance to motion on a horizontal track is small, amounting according to our latest researches to barely 4 kgr. (8.8 lb.) per ton in the case of a D. (express) train running at 100 km. (62 miles) per hour in calm weather without head or side winds. If, however, this speed were maintained on a gradient of 1 in 250, the resistance would be doubled and the engine load increased accordingly. But this gradient is only about the limiting gradient in flat country; even in traversing level valleys with gradients of say 1 in 166 or when broken country with 1 in 100 gradients has to be run over, or again when it is a question of mountainous country — with gradients of up to 1 in 40 on German main lines — the upper limit of capacity of the locomotives enforce an appreciable reduction of the speed.

Contradictory as it may at first appear, steep down gradients require equally a reduction of the speed below the maximum, not, it is true, due to insufficient power, but because reasons of safety require fuller control of the train by the brakes.

There are other features of the track which operate in a similar manner to stopping places, although to a smaller extent, by requiring the alternation of braking and accelerating periods, with short sections that have to be traversed at a reduced, although constant speed. These comprise curves of small radius, and particular stations and bridges; speed limits due to curves are necessary in principle, those due to stations and bridges being of a local character. Incidental and temporary limitations are also introduced by the progress of work on the permanent way.

Acceleration at starting.

What then can we do to improve speeds in the face of these adverse factors ? First of all brief consideration of the *acceleration period* is necessary. The starting period is reduced according as the greatest possible tractive effort per ton of train weight is available. It is not a matter of the initial movement only, but also of large efforts and outputs with increasing speed in order that the high rate of acceleration may not be restricted to the first moment of starting. This means first a comparatively large adhesive weight for the locomotives, which is the *essential condition* for a large tractive effort, and also adequate production of power which in the case of a steam locomotive denotes a large boiler.

The first requirement finds visible

expression in the six-coupled locomotives used for express trains in level country. If the station interval, even for F. D. (long-distance express trains), is diminished, as for example, in the industrial area of Rhenish Westphalia, by the close proximity of large towns the large standard express locomotives (1) show to great advantage for a high commercial speed, whereas formerly they would invariably have been considered much too heavy for a 350-ton D. (express) train, which in any case is always of lighter weight. As the station intervals become smaller, as with stopping passenger trains, the proportion of the run covered at a steady speed diminishes very much; as the acceleration period becomes more important the necessity for higher adhesive weight relative to the weight of the train, and larger power capacity, becomes more marked.

Finally when we come to metropolitan traffic the period of steady running sometimes disappears almost completely. The motor-coach train then shows itself to be unrivalled, since it gives a ratio of adhesive weight to train weight which cannot be attained by any locomotive, exceeding 0.5 for example, in the case of a train made up half of heavy motor coaches, in the strict sense, and half of light trailer coaches. This case is, of course, associated with the production of considerable power such as can be obtained without difficulty by electric traction thanks to a distribution of the effort over a number of driven axles. Motor coaches with internal combustion engines, which are at present chiefly suited to lines having little traffic or so-called feeder lines, certainly give also a large adhesive weight in relation to the total weight; but when operating with stepped gears the poor overload capacity of such engines hardly permits the steady development of high accelerations, and the speed characteristic is more like that of a train drawn by a steam locomotive.

So far we have considered only the large *relative* tractive effort called for in the hauling unit in order to obtain good acceleration at starting. If this requirement is to be combined with the necessity for *economy*, it is very undesirable to lay too much stress on large tractive effort and power. This means that the masses to be accelerated must be kept as small as is consistent with the traffic requirements. Consequently an endeavour has to be made to construct the individual coaches as lightly as possible, consistent with safety and smooth running, on the one hand, while at the same time absolutely avoiding making up the trains of more coaches from the available stock than is necessary for average traffic conditions, as it is not possible to consider constructional alterations to these vehicles.

It is inevitable that the variation in traffic will from time to time result in very poorly filled trains, but on the other hand the make-up schedule need not take into account every occasional traffic peak. In these exceptional circumstances there is no question that extra coaches, and in certain cases double heading or *special trains*, are a more economical solution than the *regular running of heavy trains* that are for the most part empty (2).

A further development of the statistics of train occupation, which have already been made use of experimentally, might certainly have valuable results as applied to passenger trains, and sometimes it is impossible to avoid hav-

(1) Cf. F. Fuchs and R. P. Wagner, *Zeitschift des V. D. I.*, vol. 70 (1926), p. 1725.

(2) The locomotive which is brought into service in cases of delay to operate at its usual maximum continuous output and to do the journey in the shortest time, is flexible enough with occasional overload to haul some extra coaches.

ing the impression that sufficient use is not yet made of the possibility of combining the third and fourth class accommodation to form a single « wooden bench » class. Passenger trains that regularly run with very few passengers could be replaced by motor coaches. And in this connection also the practice of running « through » carriages on fast trains, thereby increasing their weight, requires investigation.

Speed on gradients.

The effect of gradients operates in the same way as starting acceleration but to a more serious extent. Large tractive effort is essential, at any rate on steep grades, whereas any given train can be set in motion with reduced acceleration on the level or on a moderate gradient, with a comparatively small tractive effort. Large adhesive weight is therefore necessary, and it has not only to be adequate to the weight of the train and the other resistances to motion, but must also have a margin sufficient, for example, to accelerate the train again on a gradient after an exceptional stop. Working up long gradients at slow speeds, as with freight trains, for example, often gives rise to a steady regime of running, as against the more temporary character of the acceleration period.

Hence large adhesive weight has again to be accompanied by adequate power capacity if large tractive effort has to be exerted even at considerable speed. It is in this connection that the use of the locomotive carrying wheels is of importance, since in addition to the advantages they give for negotiating curves, they help to carry a large and powerful boiler, or in the case of electric locomotives, permit of the equivalent powerful electrical equipment. This holds good even for freight locomotives for steep sections of the line; for example the speed at which the adhesive weight can still produce the full tractive effort is 33 % higher with the heavy I. E. standard freight locomotive of the Reichsbahn (German State Railways), than with the G. 10 locomotive which has no carrying wheels, while its maximum tractive effort is still 30 % higher. The boiler output has been increased in this case not only in proportion to its greater weight, but specifically also by using a higher steam pressure and superheat. The operation of heavy express trains at high speeds on long gradients of alpine character leads to the employment, to take an extreme example, of the heavy double electric locomotives built for the St. Gothard route by the Swiss Federal Railways.

If now, this point of view can again be referred to the tractive effort and output per ton weight of train, and economic considerations are kept in mind, the desirability is seen of running trains that are no heavier than the traffic conditions demand. Given equal seating capacity the lightest vehicles should be chosen. It is for this reason, quite apart from their lower resistance to motion, that the large goods wagons (Grossgüterwagen) (3) are advantageous as their tare weight is less per ton of useful load than any other type, and their economy as regards labour costs recommends them for use in the case of all loose goods for which they are suitable. For similar reasons the light goods trains (Leig) are valuable for speeding up the transport of packages; their small mass can be started easily by old light locomotives and their gravitational resistance is so small that they often impose no reduction of speed on gradients. In fact, the available locomo-

(3) Cf. G. LAUBENHEIMER, *Zeitschrift des V. D. I.*, vol. 66 (1922), p. 885, and in *Eisenbahnwesen*, special number of *Zeitschrift des V. D. I.*, Berlin, 1925, p. 73; FLÜGEL, *Zeitschrift des V. D. I.*, vol. 68 (1924), p. 977.

tive power is frequently useless, and this has led recently to the building of *freight motor wagons,* spacious double vans with powerful internal combustion engines.

It appears, therefore, that the relation between commercial speed and maximum speed is capable of considerable improvement by on the one hand using locomotives of greater relative tractive effort and power, and that these have the added advantage on the level — i. e. when the train resistance is a minimum — of being the easiest means of increasing the maximum speed, and on the other, by permitting the train weight to be reduced as much as possible.

Shortening the shunting time.

This is another method of increasing the commercial speed of *local freight trains* without altering the maximum speed, and it is now being introduced on a large scale by the Reichsbahn. The small intermediate stations are provided with light shunting motor locomotives which are usually of about 40 to 50 H. P. (4). They take the wagons intended for their particular stations, from the main train, and conversely bring wagons up to it which have previously been assembled. In this way the use of the train locomotive for any shunting operations is eliminated, which is very desirable in view of its unnecessarily large size for such a purpose. A great deal of time is thereby saved and the journey speed between the terminal stations can be made equal to several times that represented by the very low figures hitherto obtainable.

Maximum speeds now obtained.

The preceding remarks have dealt largely with questions of principle and it is naturally desirable to apply them also to actual values of speed. The first point to be made clear in connection with conditions in Germany is that since 1928 the *Eisenbahn-Bau- und Betriebsordnung* (E. B. B. O.) (regulations in respect to construction and operation of railways) permits a maximum speed of 120 km. (75 miles) per hour on main lines under specially favourable conditions. This speed is determined to a large extent by the minimum distance of 700 m. (2 300 feet) between the distant signal and the home signal, in conjunction with the braking distance which increases nearly as the square of the speed. With our compressed air quick acting brake, a braking distance of 700 m. can actually be worked to at a speed of 120 km. per hour; longer braking distances are not permissible because there is always the possibility with poor visibility that the driver will only sight at the last moment the distant signal the approach of which is indicated by warning posts or beams (5) We can now see the interest there is of increasing the commercial speed *without* increasing the permissible maximum speed. Indeed, an increase of the maximum speed would require a respacing of all the distant signals and their indicating posts and this would be a costly matter that could only be carried out gradually in the present unfavourable financial conditions of the Reichsbahn.

Our trains do not, in fact, yet make use of this maximum speed. The schedules of most of our F. D. (long-distance express) trains show 110 km. (68.3 miles) per hour as the maximum permissible speed; the remainder of these and the majority of the D. (express) trains are timed to do 100 km. (62 miles) per hour. The quickest journey time required to make up for delays is based

(4) L. NIEDERSTRASSER, *Zeitschrift des V. D. I.*, vol. 74 (1930), p. 1697; *Verkehrstechnische Woche,* vol. 24 (1930), Nos. 44/45.

(5) RISCH, *Zeitschrift des V. D. I.*, vol. 75 (1931), No. 24, p. 761.

on these speeds; for the schedule times 4 % is added in the case of F. D. (long-distance express trains), and 7 % for ordinary express trains, so that in the first case the maximum speed is 105 km. (65 miles) per hour in round figures when running to schedule time, and the corresponding commercial speed on good stretches without severe gradients nor many large towns in close proximity is 85 to 90 km. (53 to 56 miles) per hour, in spite of the fact that there are usually a number of stations that have to be passed at reduced speed.

The question will be asked as to why advantage has not yet been taken of the maximum speed that is allowable. The reasons are that the braking distance has to be kept definitely within 700 m. (2 300 feet) and that economy of power has to be considered. The manner in which the coal consumption varies quantitatively with the speed has been known for a long time. Recent investigations have shown that an increase of 10 km. (6.2 miles) per hour, in the range of speed from 90 km. to 110 km. (56 to 68.3 miles) per hour, requires at least 10 % more coal (with a progressive tendency). Since the success of a train as a paying proposition depends on the difference between the receipts and the running costs a popular train that is known to be well filled is most able to carry higher running costs, although in that case acceleration is least necessary. As regards time tables it is of the utmost importance to pay attention to commercial requirements; for example, the earlier arrival of night expresses which might be brought about by increasing the commercial speed would be quite undesirable in most cases.

Reducing the journey time with modern express locomotives.

In order to discover how much time could be gained by using powerful locomotives without exceeding the existing limit of maximum speed, we ascertained the possible journey times between Berlin and Hambourg of F. D. (long-distance express) trains weighing 350 tons (luggage van, five express train coaches, restaurant car), when drawn by one the Reichsbahn's new 03 express locomotives, at the maximum speed of 110 km. (68.3 miles) per hour. The somewhat lighter 03 engine was chosen in preference to the 01 engine in view of the easy nature of the route; the former

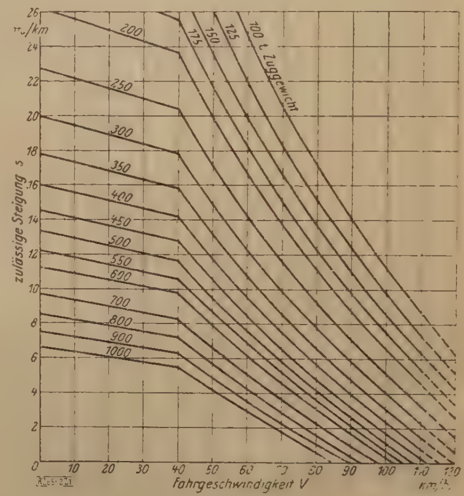

Fig. 1. — s V diagram of class 03 express locomotive of the Reichsbahn, showing the relation between the speed V, the rising gradient s and the weight of the vehicles, for continuous maximum boiler output. (The tractive effort not used on the up grade is available for acceleration.)

Note: Zulässige Steigung = Permissible gradient. — Fahrgeschwindigkeit = Running speed. — Zuggewicht = Weight of train.

could haul a 350-ton train continuously at 120 km. per hour on the level (see fig. 1). A commercial speed of little more than 100 km. (62 miles) per hour was due to several points where speed had to be reduced, with the consequent alternations of braking and accelerating periods, to starting and to cautious run-

ning into the metropolitan terminal stations. It might therefore be considered satisfactory to operate scheduled trains at 100 km. per hour and to add an allowance for delays of such an amount that on the longer sections the speed could be increased to more than 110 km. per hour when necessary, but not exceeding 120 km. per hour. With a braking distance of 700 m., the possibility of basing a time table on this speed of 120 km. per hour appears to be of doubtful interest even theoretically, quite apart from any question as to whether such a course would be permissible. Even if the more favourable table of rapid braking in the new « Technical Regulations » is used, a down gradient of only 1 in 1 000 necessitates reducing the speed to 115 km. (71.5 miles) per hour, and subsequently a comparatively long time is required to regain 120 km. (75 miles) per hour. This could actually have been done with the 01 locomotives, thus worked more carefully, or with the 03 locomotives, the weight of the train in this case being reduced to 250 or 300 tons. A commercial speed of over 100 km. per hour would mean a gain of 22 minutes in the time between Berlin and Hamburg.

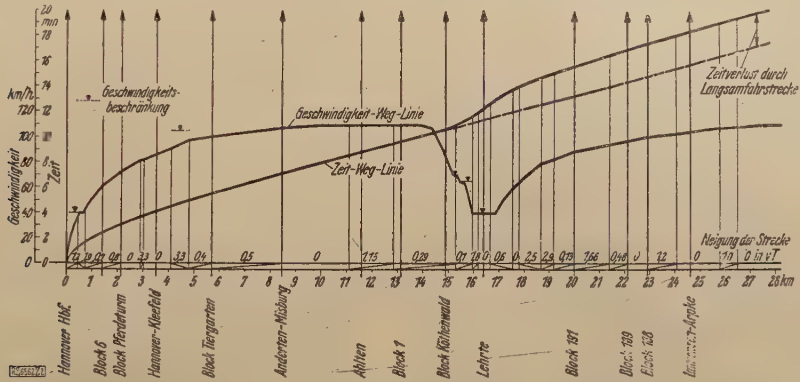

Fig. 2. — Graphical time table of a long-distance express trains (weight of the vehicles : 350 tons), hauled by a class 03 locomotive on a section of the Hanover-Berlin line; speed and journey time as a function of the distance travelled; $V_{max.}$ = 110 km. (68.3 miles) per hour.

Explanation of German terms:

Geschwindigkeitsbeschränkung = Speed restriction. — Geschwindigkeit-Weg Linie = Speed-and-distance curve. — Zeit-Weg Linie = Time-and-distance curve. — Zeitverlust durch... = Time lost on low-speed section. — Neigung..... = Gradients in millimetres per metre (1/1000).

Moreover, if a speed of 110 km. per hour were strictly adhered to, and a decrease of 4 % margin for delays, the 03 locomotives permit a noticeable improvement in time as compared with the present time tables for the less powerful S.10 engine.

Thus the time table diagram, figure 2, for the route Berlin-Hanover-Hamm (-Cologne), likewise a practically level track, gives a minimum journey time of 261 minutes (exclusive of the stops at Hanover) for the 431 km., corresponding to a commercial speed of 99 km. (61.5 miles) per hour. After adding the allowance this corresponds to a saving of about 22 minutes compared to the quickest of the present F. D. (long-distance express) trains, and of say half-an-hour for the Berlin-Cologne journey.

Obviously, a running speed of 120 km. per hour need not be considered for ordinary passenger trains, since the stock available for them is not fitted

with the Kunze-Knorr quick acting brake, and the distances between stations are as a rule much too short for such a speed to be reached. There is no advantage whatever in developing maximum speed spasmodically, and it is of importance only when maintained over long stretches of suitable track. Economic considerations are opposed to excessive maximum speeds for the reason that the very considerable kinetic energy of the train has to be dissipated by braking at every station and a correspondingly large amount of energy is necessarily absorbed in storing it up again.

In between the long distance express trains and the stopping passenger trains are the fast trains and the D. or ordinary through trains, the last-mentioned being of course more like the F. D. trains. Their more frequent stops alone render close approach to the journey speed of these privileged types of train impossible. Often their greater weight makes it uneconomic to run them at the same speed even if sufficient power were available, and moreover no great advantage would be gained. The F. D. train with its relatively low weight and infrequent stops is best suited to high average speed.

Speed restrictions.

The German regulations (E. B. B. O.) still include two kinds of speed limit that are graded in steps and apply to down grades and curves respectively. Speed limits on gradients are conditioned by the braking distance since the gravitational forces that are checked by the brakes on a down grade tend to increase the braking distance; the kinetic energy, i. e. the speed must accordingly be reduced. On the other hand, speed limits on curves are due to the necessity of maintaining the stability of the vehicle, i. e. to resist the overturning moment due to centrifugal force. The speed limitations referred to become important with the maximum speeds in use at the present day only on down grades or on sharp curves, which are frequently present together, so that any attempt at improvement by increasing the distance between the distant signal and the main signal is nullified by the curve. Certain difficult curves on otherwise easy gradients require greater superelevation, with unpleasant effects for the slower trains; alternatively they could be dealt with by small alterations in the track layout so as to secure a larger radius of curvature. These possibilities have to be investigated by the permanent way engineer, whose task it is also to consider whether many local speed limits through stations cannot be attenuated.

High-speed locomotives.

While the foregoing considerations apply to the possibilities of improvement within the present limits of permissible maximum speed, the important task still remains of discovering what speeds are attainable if the 120-km. per hour limit can be raised by modifying signal locations. The technical possibilities should be considered, not from the point of view of creating records, but from that of meeting traffic requirements. In this connection it may be recalled that as long as tweny-five years ago, two Berlin three-phase motor coaches (6) reached 200 to 210 km. (124 to 130 miles) per hour in Berlin, and a Bavarian express steam locomotive hauling a light train attained 154 km. (96 miles) per hour on level track. Even before the time when the high speed runs in Berlin were first made known, an article appeared, in

(6) O. Lasche, *Zeitschrift des V. D. I.*, vol. 45 (1901), p. 1261 and seq.; W. Reichel, same volume p. 1369 and seq.; Lochner, *Zeitschrift des V. D. I.*, vol. 46 (1902), p. 900.

Glasers Annalen (7), on steam locomotives for very high speeds, in which the well-known Austrian locomotive expert Dr. R. Sanzin pointed out, in referring to a preliminary design for a 200-km. (129 miles) per hour engine, that it was much more important to run locomotives of standard design at 120 to 130 km. (74.5 to 81 miles) per hour on suitable routes, and up to 150 km. (93 miles) per hour on slight inclines. His concluding sentence, which might have been written today, stated : « All that is needed at the moment is that locomotives should be allowed to give the performance of which they are at present capable ».

During the first few years of the present century practically no interest was shown in the question of high-speed trains (8). The runs of the high-speed motor coaches referred to above were followed, in 1904, by experimental runs made, with steam locomotives on the same route, between Marienfelde and Zossen. During these runs the simple 4-4-0 superheated locomotive, and one specially designed by Wittfeld for high speeds, attained 128 km. (79.5 miles) per hour with six corridor coaches, and 136 km. (84.5 miles) per hour with three of these coaches. A prize was offered by the Association of German Mechanical Engineers in 1902/03 for the best design of a steam express train for a normal speed of 120 km. (75 miles) per hour and a maximum speed of 150 km. (93 miles). None of the proposals ever matured because at that time there was no real call for them; they were mostly for four-cylinder engines with balanced masses, large wheels in order to avoid excessive piston speeds, and in some cases special shaping of the exterior to reduce air resistance. The Bavarian locomotive, mentioned above, may perhaps be considered a result of this scheme; it was built for exhibition purposes.

Although not entirely ignored, the matter then was kept in the background. Now, however, numerous experimental runs are again being made at speeds of 130 to 140 km. (81 to 87 miles) per hour; but they are made with the idea of testing rolling stock and brakes as well as locomotives. The standard express locomotives of the series 01 and 03, which are simple two-cylinder engines, run quite satisfactorily at 130 km. per hour, although the reciprocating masses are not fully balanced. The « Rheingold » coach has been tested up to 142 km. (88 milles) per hour; and a few months ago the new fast-train coaches ran at 140 km. per hour with entire success. The perfect riding qualities of these coaches were tested not only by personal observation but also by using the vibration tester which, with other new equipment in the rolling stock testing department in Berlin-Grunewald, enables investigations to be made into all kinds of oscillations in moving coaches; this equipment is greatly assisting the development of better riding coaches for express train service.

It is noteworthy that a speed of 140 km. per hour was attained by old four-cylinder compound locomotives (1916) and that the upper limit of speed at which coaches are to be tested is 150 km. per hour. The Bavarian S 3/6 locomotive, which is properly well-known to readers, and is also a four-cylinder compound engine with balanced masses, ran recently with complete smoothness at 138 km. (85.7 miles) per hour in spite of its rather small wheels. Paragraph 69 of the « Technical Regulations » of the Association of German Railway Administrations, which represents the experiences not only of German locomotive engineers, but also of experts from other countries, confirms that, for locomotives with a leading bogie, 340 r. p. m. is

(7) Fraenkel *Glasers Annalen*, vol. 48 (1901), p. 159; R. Sanzin, *Glasers Annalen*, vol. 49 (1901), p. 129.

(8) Cf. A. von Borries, *Zeitschrift des V. D. I.*, vol. 48 (1904), p. 949.

generally considered a suitable maximum speed; this may be increased by 10 % in the case of three-cylinder engines with cranks 120° apart and also in that of four-cylinder engines with motions working in opposite directions. This indicates that there is no fundamental difficulty in building steam locomotives with balanced masses for a speed of 150 km. per hour and running at 374 r. p. m. provided the diameter of the driving wheels is not less than 2 130 mm. (7 feet). This holds good also for electric locomotives. Detailed consideration of the points which arise in designing such locomotives in order that a proper balance may be preserved between the various requirements is beyond the scope of this article.

Fast rail motor coaches.

Only a short time ago motor coaches were considered to be of secondary importance for express or fast traffic. Their main sphere was for feeder or shuttle services with relatively small accommodation, apart from the special case of urban lines. But on various occasions more recently more ambitious claims have been put forward. The special design known as the Kruckenberg propeller coach is reputed in the Press to have attained 230 km. (143 miles) per hour recently. The information published shows that the important feature it not so much the propulsion by an air screw as the very light construction and the shaping of the car like an airship, so that the air resistance is reduced to a minimum. It remains to be seen how this kind of vehicle will adapt itself to railway service and especially whether such high speeds are permissible in routine operation from the point of view of the technical requirements of braking and signalling. On the other hand, a motor coach ordered by the Reichsbahn, equipped with Diesel-electric drive for a maximum speed of 150 km. per hour, utilises the usual form of construction, except for the stream lining to obtain low air resistance; this coach has considerable carrying capacity.

Competition between trains hauled by locomotives and rail motor coaches will, therefore, characterise the development of greatly accelerated railway traffic. In this connection, we think an important consideration, which is in favour of locomotive trains in many cases, is the manner in which a given accommodation can be provided without much affecting the working of other trains which have to be fitted into the timetable. An F. D. train has about double the seating capacity of a double motor-coach, and therefore requires only a single set of transport operations, and like any other train only a single group of overtakings, whereas with the motor-coaches these occur twice. Moreover, the cost of two large motor-coaches of this kind is approximately the same as that of an F. D. train. If we consider, for example, one of the F. D. trains that is popular and well timed for business purposes, such as the evening train from Berlin to Westphalia and the Rhineland, the required accommodation can be provided by a single train. It would appear a mistake, therefore, to assume too hastily that new types of motor-coach should be considered in preference to the locomotive which has already been highly developed and is capable of further improvement.

Final considerations.

We have limited these remarks in the main to a maximum speed of 150 km. (93 miles) per hour, and generally speaking this is hardly likely to be exceeded for some time for *regular scheduled traffic;* the reason for this is that no transport undertaking can neglect the economic side in operating its routine services. High speeds mean in the first place an increase in the power item

of the running costs; since the train resistance is not constant but increases rapidly with the speed, the energy consumption per kilometre of line also increases. It is a matter for enquiry whether the staff and the rolling stock can be utilised on the whole so much more fully at the higher speed that a smaller amount of vehicles and less labour will suffice. This is scarcely probable in view of the relatively few trains that would be run at particularly high speed for long distances. In addition to the increase in running costs due to the greater energy consumption there is also the capital outlay for rearranging the signalling. High running costs imply higher fares if the trains are not to be run at a loss, and it would be difficult to raise general enthusiasm for such a proposal amongst the people of Germany at the present time.

On the other hand, the raising of the maximum speed from the figure of 120 km. (75 miles) per hour, which is not at present taken full advantage of, to 150 km. (93 miles) per hour, i. e. by 25 % would permit a very considerable saving of time; this would improve the commercial speed in almost the same ratio thereby permitting a figure of 120 km. per hour, or thereabouts, to be reached on practically level routes (9).

The various points of view that can be adopted in considering the subject have been outlined. A number of readers may have inferred from the title that constructional proposals were to be put forward for locomotives and coaches that would be suitable for higher speeds than are actually run at the present day. In the first place, however, it may be said that revolutionary ideas are quite unnecessary in this connection. Moreover, it should be realised that by careful attention to details a great deal of improvement can be made in the commercial speed without changing present maximum speeds; the utilisation of 120 km. per hour in practical working permits still further progress to be made. The improvement of freight traffic or even of local passenger traffic has long ceased to depend upon these high speeds, and progress must, on the whole, be achieved with some degree of uniformity. The complex structure of the entire time table with all its connections cannot be transferred, without careful preparation, to a plane where higher speeds rule. Those trains which are most independent of others are in the best position and can most readily benefit from the advantages referred to. When the present signal layouts are eventually modified, possibly on privileged routes first of all, a maximum speed of 150 km. per hour, will, as we have endeavoured to show, be possible with our ordinary types of rolling stock. Whether such an advance can be accomplished without an intermediate stage, and to what extent it is likely to be economic are questions outside the present discussion.

In conclusion it may again be emphasised that better journey times can be attained in many cases by developing the principles to which attention has been drawn, and without having recourse to an appreciable increase of maximum speed.

(9) Certain speed restrictions would perhaps still have to be retained, on curves or in stations that would have a more noticeable effect with increased speeds.

NEW BOOKS AND PUBLICATIONS.

[385. (02]

Universal Directory of Railway Officials, 1932. — London, S. W. 1. The Directory Publishing Co. Ltd., 33, Tothill Street, Westminster, 1 vol. 8 5/8 in. × 5 1/2 in. × 1 in. (Price : 20 sh. nett.).

The 38th annual edition of *The Universal Directory of Railway Officials* has now been issued. It has been compiled chiefly from official sources, under the direction of the Editor of *The Railway Gazette.* It contains a complete list of all the chief railway officials all over the world.

The *Directory* is divided into eleven sections arranged as follows : Official, Great Britain, Ireland, Europe, Asia, Africa, Australasia, North America, Central America, Mexico and West Indies, South America, and Personal Index of Railway Officials.

Many engineering firms doing business with railways in Great Britain and abroad have the Universal Directory of Railway Officials in constant use throughout the year in connection with correspondence, as it is the only directory which enables one to find the right railway, and the right officer at the right moment.